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White Teachers of Diverse STEM Students: Learning Progressions Towards or Away From Culturally Relevant STEM Education

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To the Graduate Council:

I am submitting herewith a dissertation written by Amelia Adams Brown entitled "White Teachers of Diverse STEM Students: Learning Progressions Towards or Away From Culturally Relevant STEM Education." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

Mehmet Aydeniz, Major Professor

We have read this dissertation and recommend its acceptance:

Susan Benner, Lynn Hodge, Judson Laughter, Gary Skolits

Accepted for the Council:

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(Original signatures are on file with official student records.)

White Teachers of Diverse STEM Students:
Learning Progressions Towards or Away From Culturally Relevant STEM Education

A Dissertation Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Amelia Adams Brown

December 2018

Dedication

This is dedicated to my family.

To my husband, whose hard work, career, and support have allowed this pathway to even be an option for me.

To my sister, not only the most talented educator that I know, but also the single-most supportive and encouraging person on the planet.

To my parents, step-parents, and in-law parents, who, although they all live at least a day's drive away, have countless times come and taken my kids for a weekend, or a week, or more, so that I could work towards accomplishing this goal.

Most of all, to my kids, who are incredible, smart, funny, talented world-changers despite me, not because of me. They have endured hardships beyond their years due to my decision to pursue this degree: countless hours with babysitters, staying up late past bedtime on school nights to attend classes with me, missing school entirely to stay with family so I could attend conferences, and missing out on countless activities that other kids get to do because of the time and financial pressures I placed on my family by deciding to go back to school. Not to mention having a pre-occupied and confused mom for the past three and a half years. I did the math: I have been a Masters or Doctoral student for 51.8% of my daughter's life, and 92.9% of my son's life. I hopefully will be parenting without a computer in my lap in the near future.

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Abstract

The United States currently reports significant under-representations of people identifying as Black and Hispanic in Science, Technology, Engineering, and Mathematics (STEM) education and careers. As a result, research abounds on the achievement, participation, and motivation gaps that exist between diverse populations in STEM education and careers, and the important role of K-12 STEM teachers in fostering and providing equitable STEM education for all students. One additional factor into the current research on this topic is the predominantly White STEM teaching force. Combined with the documented racial and ethnic participation gaps in STEM education and careers, this naturally raises questions and concerns regarding the abilities of White STEM teachers to equitably teach and motivate diverse students. Culturally relevant STEM teaching can help bridge the racial and cultural divide between teacher and students, but often White STEM teachers struggle to utilize culturally relevant education in their classrooms.

This critical comparative case study focuses on the multiple influences that secondary STEM teachers experience in relation to enacting culturally relevant STEM teaching practices. The findings of this study support the idea that being a practitioner of CRE is a continuum, not a binary. This study also finds that teachers can display proficiencies in CRE even when they did not self-report these proficiencies. Additionally, closer examination of the multiple influences on teachers' abilities to be practitioners of CRE finds that these influences can be either inhibitors or catalysts of the ability to actualize CRE in the STEM classroom. Examining these multiple influences results in recommendations to further the use of culturally relevant STEM education. Capitalizing on these recommendations could have the future impact of an increasingly equitable STEM teaching force better prepared to motivate all students towards STEM higher education and careers.

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Chapter 1: Introduction

Statement of the Problem

In the United States, Black Americans and persons with Hispanic heritage are reported to participate in Science, Technology, Engineering, and Mathematics (STEM) fields in both post-secondary education and careers at much lower rates than their White counterparts (Burke & Mattis, 2007). Some examples include the National Academy of Engineering data from 2011, showing that racial minorities comprise over 30% college-age students in the United States, yet make up less than 13% of the awarded engineering degrees (Vest, 2011). This trend continues past the college years and into career choices, as shown by a synthesis of data from the National Academy of Sciences which reports that although 28% of the national population are racial minorities comprise, these same race-identified groups account for a mere nine percent of employed STEM professionals (NAS, 2011).

As both Black and Hispanic Americans are underrepresented in STEM fields, this makes these particular racial and ethnic populations a potential growth area in STEM education (Burke & Mattis, 2007). In efforts to address this participation gap, funds and effort are increasingly being allocated towards recruitment of students of Color into STEM fields such as math and science (Rothwell, 2014). However, National Center for Education Statistics (NCES) reports show that even if Black and Hispanic students enter STEM fields in college, they are more likely to drop out or change majors than their White counterparts (Chen & Soldner, 2013). Recruitment into STEM fields of study will not address this documented participation gap without the motivation to persist in a STEM education field, and then the ability to convert a STEM education into a STEM career.

Secondary STEM teachers play an important role in motivating students to pursue STEM courses of study in higher education that lead to STEM careers. The unique importance of secondary years in shaping student attitudes and motivations towards STEM fields is well researched and documented (Amador & Soule, 2015; Choi & Chang, 2011; Knezek, Christensen, & Tyler-Wood, 2015; Lee & Shute, 2010). Studies also show that school climate, which is directly sculpted and impacted by the teachers within that school, is a major variable in crafting student attitudes and motivations to pursue STEM education in High School and beyond (Choi & Chang, 2011; Lee & Shute, 2010). Admittedly, the role of teachers in motivating students to pursue STEM careers is certainly not the only factor or input in a student's career trajectory. However, the STEM teacher's role in these life choices can be an important and impactful, and should not be minimized or underestimated.

However, a teacher's effect on student motivations towards STEM is not always positive. With the documented underrepresentation of Black and Hispanic races and ethnicities in STEM careers, coupled with the role of secondary teachers in motivating students to pursue STEM careers, it appears that secondary teachers are more efficient at motivating White students to pursue STEM careers than Black or Hispanic students. One reason could be that secondary STEM teachers are predominantly White. Data from the U.S. Department of Education (USDE) shows that as recently as 2012, only seven percent of public school teachers are African-American (as compared to 16% of African-American public school students). This divide widens even more for Hispanic ethnicities; 24% of public school students are Hispanic while just eight percent of teachers share this ethnicity. Similar to the trend of attrition in STEM careers, teachers of Color are also leaving the classroom at higher rates than their White colleagues (USDE, 2016).

The correlation between a disproportionately White teaching force and the educational outcomes gap regarding Black and Hispanic students has not gone unnoticed. Recently, authors and researchers have explored the role and responsibility of White teachers of diverse students across many subject areas and in general fields of education (Delpit, 2013; Emdin, 2016; Picower, 2009). While the intersections of a White-dominated workforce with a population of increasingly diverse students is a popular research topic in education as a whole, little research is focused on this same topic in STEM education. With the acknowledged presence of STEM college and career under-representations among Black and Hispanic students, recognizing and investigating the relationship between the disproportionately White STEM teaching force and the participation gaps of minorities in STEM fields becomes a research mandate.

The obstacles present for White teachers reaching diverse students are well documented (Delpit, 2013; Emdin, 2016; Picower, 2009). Theories toward overcoming these obstacles are widely published (Gay, 2002, 2013; Ladson-Billings, 1994, 1995a, 1995b, 1998, 2001, 2006, 2014). Yet, the actual pathways for overcoming these obstacles are not well defined in the practitioner realm of many subject areas, including STEM fields (Young, 2010). This study looks to help fill this research gap by describing the learning pathways of White STEM teachers in relation to culturally relevant teaching in diverse classrooms.

Research Question

In this study, the following central question will be addressed:

- What are the major influences and experiences that shape an educator into a practitioner or non-practitioner of culturally relevant STEM teaching?

Purpose of the Study

The documented racial participation gaps in STEM careers (Chen & Soldner, 2013; NAS, 2011; Vest, 2011), the recognized importance of secondary STEM teachers in motivating students to pursue STEM careers (Amador & Soule, 2015; Choi & Chang, 2011; Knezek, Christensen, & Tyler-Wood, 2015; Lee & Shute, 2010), combined with the overwhelmingly White STEM teaching force (USDE, 2016) naturally raises concerns about how and why STEM teachers are failing to foster motivation among Black and Hispanic students to pursue STEM careers at the same rates as their White classmates. One strategy teachers can employ to improve achievement for all STEM students, and thus aim to increase interest among all students for pursuing STEM fields in higher education or occupations, is using culturally relevant STEM pedagogy (Ferrare & Hora, 2014). While this is a well-respected pedagogical methodology to engage students otherwise marginalized or underrepresented in academic pursuits, many secondary STEM classrooms struggle or fail to incorporate elements of culturally relevant STEM education (Adams & Laughter, 2012; Fasching-Varner & Seriki, 2012; Laughter & Adams, 2012; Nam, Roehrig, Kern, & Reynolds, 2013; Ukpokodu, 2011).

Given the disconnect between theory and practice, and the documented struggles teachers face when looking to enact theory in the STEM classroom, the purpose of this study is to describe the multiple influences of the learning process towards becoming, or not becoming, a culturally relevant STEM teacher. These multiple influences include, but are not limited to, a teacher's own secondary STEM educational experience, the teacher preparatory experience, the teacher's current teaching environment, as well as the overall context and culture in which all of these experiences take place. Understanding the learning progression and the enactment of agency that educators undergo towards or away from cultural relevance is paramount in

understanding how to encourage more STEM teachers to incorporate culturally relevant classroom practices. Encouraging more STEM teachers to utilize teaching methods that lead all students towards STEM proficiency is an essential component of closing the participation gap among Black and Hispanic students in STEM fields, as this study recognizes the important role of STEM teachers in motivating students to pursue STEM education and careers.

Significance of Study

This study looks to add to the body of research on culturally relevant STEM education in three meaningful ways: by expanding investigations into culturally relevant education beyond practitioners of culturally relevant education, by describing long-term learning progressions rather than short-term interventions, and by adding to the existing body of culturally relevant STEM education research in a way that goes beyond describing specific examples of CRE in STEM.

Research on culturally relevant education often centers on educators with a pre-existing interest or inclination towards implementing aspects of cultural relevance in their classrooms (Byrd, 2016, 2017, 2018). This is understandable, given that a purposive research participant sample of culturally relevant educators would be needed to investigate culturally relevant practices in the classroom. This study takes a different approach, however, not limiting participation to those who enact (or claim to enact) tenets of culturally relevant education. Instead, in recognition of the documented disconnect between theory and practice of culturally relevant education, this study investigates and describes the factors that influence both the development and/or non-development of a culturally relevant educator. In this study, the experiences and learning progressions of STEM teachers who are non-practitioners of culturally

relevant practices are as important and meaningful as the experiences and learning progressions of teachers who are active practitioners of culturally relevant practices.

In addition to focusing on teachers inclined to involve cultural relevance in their classrooms, existing research on this topic often centers on describing the process, procedure, or impact of a single intervention. This study rests on an underlying assumption that there is no one experience that shapes the attitudes and dispositions of a teacher, but instead that multiple influences over time impact an educator's values and priorities. By investigating these multiple influences in teachers who are both practitioners and non-practitioners of culturally relevant STEM education, this study aims to describe themes in influence towards and away from the enactment of culturally relevant STEM education.

Finally, existing research describing culturally relevant STEM education are often situated in a particular culture, a particular grade, and a particular STEM content area. This type of research supplies useful examples of culturally relevant STEM education to peers who teach in the same culture, the same grade, and the same subject. Yet, these examples are largely not applicable as examples to other cultures, grades, or STEM subjects. Given the almost incalculable combinations and permutations of STEM content area, grade spans, and cultures - it seems impossible that examples of CRE will be assembled and researched for all of these possibilities. Thus, figuring out what leads to STEM teachers conceptualizing and enacting CRE, in addition to providing specific examples of interventions, becomes a valid topic of research in culturally relevant STEM education.

Limitations of the Study

As with many social and educational research projects, the unique cases examined in this research are not necessarily universal or generalizable on a large scale. However, this research does identify themes that are applicable beyond the immediate scope of the project.

This research centers on STEM teachers, and the data collected was largely generated by STEM teacher research participants via survey and interview responses. This research thus relies on the honesty and transparency of the participant responses. The use of member-checking, data triangulation, and purposive sampling to ensure the data quality are outlined in the Chapter 3: Methodology.

Although were made to collect data regarding the multiple influences into each participant's unique learning pathway, I recognize that not all possible influences were able to be described, catalogued, and analyzed as a part of this research.

Finally, this research focuses on the interplay of a disproportionately White teaching force with an increasingly diverse student population. Thus, this study centers the relationship between race or ethnicity and STEM motivations and achievement. However, race is not the only factor to consider when looking at under-representations in STEM education and careers; identifiers such as gender and socio-economic status also show marked STEM participation gaps. In focusing on race and ethnicity in this study, I recognize the inherent risk of ignoring the intersectionality present in STEM educational inequity. This study is designed to center race as a particularly interesting case study, given the concurrent presence of a disproportionately White teaching force. The same tension does not exist for the documented under-representations of women in STEM education and careers, as the same teaching force largely identifies as female. I recognize that focusing this study on the influence of race rather than intersectionality in STEM

equity might be seen as a limitation, but I contend it was necessary to center race for the purpose of this particular study. Research findings that point to intersectional STEM equity issues were not excluded in this research, and are presented in Chapter 4.

Summary

As previously discussed, STEM subject areas are fraught with equity issues. With the potential of culturally relevant STEM education to help White teachers more equitably teach their increasingly diverse STEM students, this research centers on describing the multiple influences regarding teachers' decisions to enact, or not, culturally relevant STEM education. Before explaining the methods used to investigate this topic, I review the evolution of culturally relevant education, the applicability of culturally relevant education to STEM education, the current state of culturally relevant STEM education, and implications of the underuse of culturally relevant education.

Chapter 2: Literature Review and Analysis

This proposed research study centers of the use, or lack of use, of culturally relevant education in the STEM classroom as a response to endemic issues of inequity present in the STEM fields. Resultantly, I begin this review of pertinent literature on this research topic by explaining the development and background literature regarding culturally relevant education.

Teaching for social justice in the STEM content area includes various labels for the philosophical approaches and teaching interventions commonly supported as good practices for educational equity. While many of these terms are used interchangeably in both professional literature and in practitioner conversations on the topic, clear definitions and delineations exist. Two of these approaches, culturally relevant pedagogy and culturally responsive teaching, will be defined and explained further as the basis for culturally relevant education.

Evolution of Culturally Relevant Education: Culturally Relevant Pedagogy

Culturally relevant pedagogy (CRP) is the pedagogical framework described by Ladson-Billings (1994, 1995a, 1995b, 1998, 2001, 2006, 2014, 2017) as effective teaching philosophy for diverse students across multiple subject areas.

Ladson-Billings (1994) summarized much of her research about the necessity of overlapping cultural relevance and teaching in *The Dreamkeepers: Successful Teachers of African American Students*. In *Dreamkeepers*, Ladson-Billings (1994) argued that culture in the classroom is an essential component needed to address systemic inequities in education, and goes on to describe multiple examples of cultural relevance in various subject areas. Ladson-Billings expanded on the rationale and teaching presented in *Dreamkeepers* with two articles (1995a, 1995b) expanding these observations into a well-described pedagogical framework that she labeled culturally relevant pedagogy (CRP).

In her studies of teachers identified by both parents and administrators as excellent practitioners of CRP, Ladson-Billings (1995a) explained that instead of finding consistent teaching strategies or methods uniformly employed by these teachers, she found their similarities in the “philosophical and ideological underpinnings of their practice” (p. 162), such as how they related to and reflected upon their profession, students, and community. These keystones are identified as combination of students’ abilities to experience academic success, development of cultural competence, and critical/sociopolitical consciousness (Ladson-Billings, 1995a). Each of these three indicators are discussed individually below, beginning with academic success.

Academic Success

The first component of the CRP model is *academic success*. Ladson-Billings makes clear that academic skills and mastery of content-specific concepts must be central to any educational endeavor with this tenet of CRP: “The way those skills are developed may vary, but all students need literacy, numeracy, technological, social, and political skills in order to be active participants in a democracy” (Ladson-Billings, 1995a, p. 160). Ladson-Billings (1995b) further explains that “no theory of pedagogy can escape this reality” that “students must achieve” (p. 475).

The term achievement has multiple interpretations, and in the field of education, is often defined (for better or worse) based on growth and achievement measures derived from standardized test scores. Ladson-Billings (1995b) warns against the reduction of her tenet of academic success to a standardized test measurement, explaining that evidence of academic achievement takes multiple forms in the classroom, including students demonstrating “ability to read, write, speak, compute, pose and solve problems at sophisticated levels . . . and engage in peer review of problem solutions” (1995b, p. 475). In more recent reflections on the academic

success component of CRP, Ladson-Billings (2012) points out that often academic success is indeed reduced and simplified to standardized test achievement. Additionally, Ladson-Billings (2006) argues that focus on standardized test measures, to the exclusion other described aspects of academic achievement as well as the other tenets of CRP, is one of the missed opportunities in failing to address systemic and persistent educational equity concerns.

In light of these confusions and reductions of her call for academic achievement, Ladson-Billings (2017) recently expanded her explanations of academic success in the STEM fields to include the concept of teaching to mastery. Her statements on the topic included clarifying academic achievement as student learning, and defining student learning as “demonstrable growth in requisite subject areas” (Ladson-Billings, 2017). Ladson-Billings (2017) urged STEM teachers to beware of the gap between what students learn and what teachers cover; if STEM teachers follow standards or syllabi as a checklist of learning events without regard for what students are conceptualizing from these experiences, the opportunity for academic success of all students is diminished. Ladson-Billings (2017) criticized the association of high failure rates with high rigor, and explained that conceptualizing the theory of CRP does not allow teachers to view their courses as “sieves” that only allow a certain, intrinsically talented group of students through. Thus, the academic success component is more clearly defined in the STEM fields as growth leading towards mastery of content components, facilitated by an educator who believes that all students can and must succeed in the classroom.

Cultural Competence

The second component of CRP is *cultural competence*. Cultural competence is described as students’ ability to maintain their “cultural integrity” in the process of experiencing academic success (Ladson-Billings, 1995a, p. 161). This definition was inspired by research on the

inherent school culture dominance by the majority participant culture, and the tensions that exist when diverse students attempt achievement in a school culture that is different from their home and personal culture (Ladson-Billings, 1995a, 1995b). While Ladson-Billings offers suggestions of what teachers can do to foster cultural competence in their students, it is notable that this tenet of CRP primarily reflects the cultural competence that students develop and maintain.

As with the concept of academic success, Ladson-Billings' more recent reflections on cultural competence seek to both clarify and update. In 2014, Ladson-Billings expanded the notion of cultural competence from students maintaining cultural appreciation and integrity for their own culture and also "gaining knowledge of and fluency in at least one other culture" (p. 75). For students who are a member of the non-dominant race or culture, this generally means maintaining their cultural integrity while gaining competence in the dominant culture. However, this change was made to clarify that students of the dominant culture of an educational setting, who do not have the struggle to maintain cultural integrity (as that is maintained for them by the culture of the system), are not exempt from the requirement of cultural competence. To be specific, in a classroom that truly conceptualizes and practices culturally relevant pedagogy, White students, too, must develop cultural competence. Additionally, Ladson-Billings (1995a) is clear that cultural competence cannot be sacrificed for academic achievement - both must coexist and coevolve.

In STEM fields specifically, Ladson-Billings (2017) outlined the importance of recognizing cultural competence as a skill set that is respected and taught in schools. Given the global nature of STEM careers and economy, Ladson-Billings (2017) urged teacher educators to recognize the power of students leaving school as multiculturally (or at least biculturally) competent. However, Ladson-Billings (2017) also recognized the difficulty of enacting this

vision, posing the question *how can we develop culturally competent students if our teachers are culturally incompetent?*

Critical/Sociopolitical Consciousness

The final component of CRP is *critical consciousness*, also referred to as *sociopolitical consciousness*. Ladson-Billings (1995a) explained that “beyond these individual characteristics of academic achievement and cultural competence, students must develop a broader sociopolitical consciousness that allows them to critique the cultural norms, values, morals, and institutions that produce and maintain social inequities” (p. 162). This is further described as helping “students recognize, understand, and critique current social inequities” (Ladson-Billings, 1995b, p. 476) and “the ability to take learning beyond the confines of the classroom using school knowledge and skills to identify, analyze, and solve real-world problems” (Ladson-Billings, 2014, p. 75). For teachers looking to implement CRP in their classrooms, this is the often-missing component: the lack of encouraging “students to consider critical perspectives on policies and practices that may have direct impact on their lives and communities” (Ladson-Billings, 2014, p. 78). One method to encourage this development in students is for the teacher to model critique of social and political constructs. But again, a lack of visible, apparent sociopolitical consciousness demonstrated by the teacher leads to the lack of development of this consciousness among students (Ladson-Billings, 2014).

Ladson-Billings (2017) expanded that this lack of focus on student critical/sociopolitical consciousness often leads to decline of student interest and engagement in the STEM classroom. Ladson-Billings (2017) observed that students, from young ages, frequently ask why they are learning what they are learning in the classroom. When teachers do not have concrete examples of how the learning connects with the student’s lived experiences, such as impact on student

lives or communities, students tend to regress to a model of learning that involves rote memorization rather than meaningful knowledge construction as a foundation for lifelong learning. Thus, persistence and motivation in STEM fields relates to this tenet of CRP.

Evolution of Culturally Relevant Education: Cultural Responsiveness

In addition to CRP, *cultural responsiveness* (and culturally responsive teaching) influenced the development of the culturally relevant education framework. Cultural responsiveness in STEM teaching is defined as “using knowledge about culture and life experiences of students to structure learning that is conducive to their needs” (Wallace & Brand, 2012). This STEM-specific definition is clearly based on Geneva Gay’s (2002) description of cultural responsiveness: “using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching more effectively” (p. 106). Gay (2002) asserts that using culturally responsive teaching leads to higher student achievement and increased student motivation to learn. Gay (2013) outlined requirements of teachers who wish to teach in a culturally responsive manner, including having a mindset void of deficit views of students, becoming teacher-leaders in the implementation of cultural responsiveness, recognizing the cultural context of all learning, and intentionally connecting culture to specific subjects or skills in the classroom.

Other indicators of culturally responsive teaching include teachers being culturally aware (both in self and for their students), valuing diversity and differences, implementing culture into curriculum, maintaining high expectations for all students, and acting as a facilitator for student-centered learning (Rychly & Graves, 2012). Additional characteristics of culturally responsive teachers include the importance of habitual practitioner reflection, use of evidence-based

practices, flexibility, and commitment to personal and professional growth (Rychly & Graves, 2012).

Although the terms cultural responsiveness and cultural relevance are sometimes used interchangeably, these are related but not congruent terms. Ladson-Billing's describes culturally relevant *pedagogy*: the underlying theories, principles and sciences involved in effective teaching practice. As effective teaching practice is centered on student outcomes, CRP describes what students should experience in the classroom as a result of impactful pedagogical practices. Gay describes teaching *methods*: specific examples of experiences and interventions that teachers conduct in the classroom. Gay's descriptions of cultural responsiveness focus on the teacher's enactment of attitudes, behaviors, and activities that promote equity. Yet the real world classroom is not solely student-centered or teacher-centered; it is a contextual dynamic between student and teacher, theory and practice, pedagogy and methodology. The need to marry these diverse and multifaceted approaches to equity education exists. Evidence of fusing these approaches, in the context of moving theory into practice, are found in the framework of culturally relevant education (Aronson & Laughter, 2016).

Culturally Relevant Education

Ladson-Billings (2014) argues for the need to continually re-visit and re-examine theoretical and pedagogical perspectives that center around culture, as culture is itself dynamic and continually changing. Culturally relevant education (CRE) is an emergent label in this call for updating theory, and the result of an effort to find overlap in the theoretical traditions of social justice education (Aronson & Laughter, 2016; Dover, 2013). Additionally, while the theoretical underpinnings of teaching for social justice are important, so is the reality of what educators understand the philosophy to be, and what they are able to enact in the classroom.

The coevolution of culturally relevant pedagogy and culturally responsive teaching to culturally relevant education originated as a result of studying what, exactly, social justice educators conceptualize regarding the theory that informs their practice, and how this conception translates to classroom practice and student outcomes (Dover, 2013). The findings show three main themes relating to how teachers reported using the underlying theory in their classroom practice: commitment to “multicultural, socially conscious” curriculum firmly rooted in content-area standards, pedagogy focused on student growth involving “critical thinking and inquiry-based instruction,” and teacher’s own involvement in and promotion of student social actions. (Dover, 2013, p. 8).

Aronson and Laughter (2016) add to this concept of CRE by applying the term to multiple subject areas, including math and science. The model of culturally relevant education described by Aronson and Laughter (2016) focuses on four indicators: Academic Skills and Concepts, Critical Reflection, Cultural Competence, and Critique of Discourses of Power. The tenets of culturally relevant education are a result of synthesizing what students should be experiencing in the classroom (from Ladson-Billing’s CRP), what teachers should be doing in the classroom (from Gay’s culturally responsive teaching), and what actually happens in the classroom when teachers are motivated to enact equity and social-justice minded educational practices (Dover, 2013, Aronson and Laughter 2016). These tenets include the following:

- Student development of Academic Skills and Concepts facilitated by the teacher actively connecting culture and context to classroom learning,
- Student and teacher co-development of Cultural Competence in the classroom,
- Teacher participation in Critical Reflection with input from students to inform classroom instruction, and

- Teacher participation in Critique of Discourses of Power, both in the classroom with student-participants and in life outside the classroom (Aronson & Laughter, 2016).

Now that the background and principles of CRE are explained, I present the applicability of CRE to the STEM content areas. As CRE ascribes to four principals, I explore each aspect of CRE and explain how research supports their applicability in STEM teaching and learning. Additionally, I will describe examples of each tenet's use and alignment in STEM education.

Academic Skills and Concepts

CRE explains the need for students to achieve academic success by mastering skills and concepts tied to both content area standards and connected to cultural ways of knowing.

Teaching to standards and content mastery is one example of the alignment of the CRE tenet of Academic Skills and Concepts with best practices in the STEM classroom.

Given the educational policy climate in which we exist, the sometimes extreme focus on learning standards is often criticized for its relation to standardized testing and standardized curriculum (Sleeter & Carmona, 2017). However, it is important to note that *standards-based* and *standardization* are not the same thing. Additionally, there is paramount importance of mastering content-area standards in STEM fields. Due to the building nature of STEM fields, it is necessary that students achieve mastery of academic concepts. Secondary STEM students are exposed to specialized and diverse science content with the expectation that they will build upon previously obtained STEM knowledge (Anderman & Sinatra, 2009). Students who do not achieve mastery of standards in the STEM classroom risk being left behind.

The struggle associated with falling behind in math or science is one that many students never recover from, both academically and motivationally. Research on the ACT family of assessments from grades 4-12 shows that students who are below expected performance

indicators at the fourth or eighth grade benchmark for math and science rarely achieved *on-track* status in subsequent exams; depending on the school context and demographic, the percentage of students recovering to the proficient level from basic or below-basic performance on previous benchmarks varied from 10-23% (Dougherty & Fleming, 2012). Absence of academic achievement is well-documented as a predictor of lack of motivation to proceed in an educational endeavor or content area (Legault, Green-Demers, & Pelletier, 2006).

As lack of motivation to persist in STEM education and careers is one of the educational inequities that informs this research, it is imperative that STEM teachers ensure the academic success of their students in order to support this very motivation. To ensure academic success, STEM teachers have a mandate to catalyze student mastery of Academic Skills and Concepts as identified by their content area standards. Culturally relevant STEM education should thus become less of a list of classroom lessons, activities, and labs that students need to experience, and more of a portfolio of student content-specific learning and accomplishment.

Ladson-Billings (2017) described an example of enacting the CRE tenet of Academic Skills and Concepts in an anatomy and physiology classroom setting. The teacher outlined the learning expectations from a cadaver dissection activity, and placed students into groups to complete the activity. Students were instructed that, following the completion of the dissection, two students would be selected at random from their group to take the examination on the learning standards for the entire group. This way, the teacher encouraged active construction of classroom culture that ensured the success and academic achievement of all students, not just those predisposed to succeed in the classroom context.

A discussion of obtaining academic mastery of skills and concepts in the context of teaching for social justice and education equity must also take into consideration stereotypes.

Malcom (2015) laments that stereotypes specifically related to science education influence how individuals are viewed: if they are first seen in relation to an externally-perceived identity such as race or gender, or if they are first seen as a science peer or professional. Malcom (2015) further reports that this external identity is often conceptualized before ability.

Yet stereotypes are not simply how an individual is externally perceived, but stereotypes also make an impact on the physical and educational well-being of members of the stereotyped group. Stereotype threat is the idea that members of a socially-stereotyped group (often people of minority or non-dominant races, ethnicities, or genders) experience stress, undue pressures, or anxiety as a result of identifying with the stereotyped group (Blascovich, Spencer, Quinn, & Steele, 2001; Steele & Aronson, 1995).

Stereotype threat can present itself in multiple forms, including high blood pressure (Blascovich et al., 2001). More specific to STEM fields, performance on standardized math tests below both measured ability of the stereotyped group and performance of non-stereotyped contemporaries is a measured effect of stereotype threat. (Spencer, Steele, & Quinn, 1999; Steele & Aronson, 1995). Thus, any conversation regarding academic success must take into account the impact of stereotype threat on academic performance, and any framework professing to promote equitable educational outcomes must also recognize the role of cultural competence in reaching this goal. Ladson-Billings (1995a) indeed recognized that academic success and cultural competence need to coexist, and that one cannot exist in a culturally relevant educational setting to the sacrifice of the other.

Cultural Competence

The Cultural Competence tenet of CRE obliges students and teachers to co-develop and maintain Cultural Competence in the classroom, meaning a cultivation of respect, understanding,

and acceptance of both one's own culture as well as the culture of others. In the context of classroom-based responses to inequities to STEM education, the concepts of Cultural Competence overlap with a dominant theme in the current literature regarding educational STEM inequities: teaching for identity construction and development (Varelas, Martin, & Kane, 2013). Identity in STEM is also defined as the ability of students "to see themselves as the kind of people who could be legitimate participants in STEM through their interest, abilities, race, gender, and culture" (Hughes, Nzekwe, and Molyneaux, 2013, p. 1980) As students progress through their STEM educational experiences, Varelas et al. (2013) state that identity construction is the "development of reasoned, coordinated, coherent, and meaningful ways of seeing one's self in relation to communities" such as a classroom community-of-practice (p. 319).

Learning respective of identity development stems from Vygotsky's theory of socioculturalism, which posits that all educational or learning processes have social foundations and underpinnings (Dimitriadis & Kamberelis, 2006). Additionally, Vygotsky's socioculturalism understands that learning has an integral relationship not only with a student's social realm, but also the student's cultural and lived experiences (Dimitriadis & Kamberelis, 2006). Applying these sociocultural concepts to STEM teaching and learning is a popular research topic while investigating a students' lack of identifying with a subject, which can lead to less motivation to succeed and persist in that subject area.

Bricker and Bell (2013) investigated the relationships and intersections of STEM learning and values, cultural norms, student interest, and student identity. Specifically, they looked more at how these various impacts influenced both expertise development and identity development related to STEM. This study found that, in agreement with a sociocultural lens, both classroom and lived experiences led to the STEM learning progression of the participant, but that there

were multiple missed opportunities to bridge lived experiences with school-based tasks. In fact, Bricker and Bell (2013) mention that based on these missed opportunities, the school experiences in STEM learning were at times even disruptive to the student's STEM learning and identity pathway by not being responsive of culture and context. In the context that Bricker and Bell (2013) describe, it appears that the integration of Cultural Competence into school-based STEM learning would ease the oft-troubled transition between school and lived experiences to facilitate not just the student's STEM learning, but also their identity as a STEM practitioner.

Tan, Barton, Kang, and O'Neill (2013) note that even though standardized test scores show similar achievement levels, female students of Color do not identify with scientists-in-practice, and that this void of identity leads to the documented participation gap among non-White girls in STEM careers. Tan et al. (2013) chose to research the articulation (both narrated and embodied) of STEM identity in non-White middle-grades girls. Tan et al. (2013) found similar missed opportunities in development of STEM identity, such as the inability to bring together lived science and school science, and not perceiving oneself as capable of a STEM career based on lack of achievement (or, even more troubling, lack of recognition of achievement). Tan et al. (2013) conclude that race, class, gender, and socioeconomic status influenced participant identity with science, and that this self-conception was "critical" to how the participants "moved forward (or not) with an interest in science" (p. 1169).

Tan et al. (2013) also warn that "institutional narratives in the forms of grades, certificates, or a teacher's labeling of a student wield much power in reifying or supplanting" the identity personifications of participants (p. 1172). This warning especially speaks to the need for CRE in the STEM classroom; as a teacher's unawareness of centering his/her own culture in the

classroom leads to the disenfranchisement and demotivation of those who do not identify with the dominant classroom culture.

Wong (2015) investigated how identity regarding race and ethnicity impact STEM career goals. This study looked at career aspirations both directly in science (with daily use and application of science skills and knowledge), and from science (which includes many STEM careers which use scientific knowledge as well as an additional skill and knowledge base). Wong (2015) explained their findings in terms of how identities, like ethnicity, “can potentially contribute to the lack of identification among minority ethnic students towards careers in science” (p. 990). Some components of this lack of science identity are easy to conceptualize, like Wong’s (2015) description of a student of Color who does not identify with a science career, when asked to elaborate, explained that “all I’ve ever seen before is a White scientist.” (p. 990). Other identity tensions become more complex, as observed by Bricker and Bell (2013), Tan et al. (2013) and Wong (2015); as when multiple structural identities are layered with multiple structural inequalities, such as the intersectionality of being both non-White and female.

The complex nature of identity development ensures that it does not happen in a vacuum, instead identity learning is context-dependent. When the context of learning is STEM classrooms, the structure of the learning environment facilitated by the classroom teacher plays a key role in respecting identity development as a part of teaching and learning. The role of the educator in an identity-respecting environment is identical to the role of an educator in a culturally competent environment: promoting, celebrating, and facilitating connections between students, culture, context, and content.

Examples of the duality of teaching for Cultural Competence tenet of CRE and identity development are not found in descriptions of lesson plans, but instead, in teacher philosophy that

influences classroom practice and in student outcomes. First, teachers would need to recognize the dominant culture and/or power structures that influence their institutional narrative, and resist this tyranny of the majority. One example of this is the (in)famous science/STEM fair and the required project that a student must come up with in order to participate. As historically assigned, these projects are less of a showcase of content area knowledge or talent, and more of a display of access and privilege (Czerniak & Lumpe, 1996, Salter, 2013).

An additional example is teacher's recognition that provided support materials (texts, videos, lab kits, etc.) are often perpetrators of inequity stereotypes (Cegle & Olivares, 2012; Tanner, 2009). These inequity stereotypes, if left un-confronted by the teacher in the classroom, have the potential to damage both Cultural Competence and identity construction. And finally, the best example would be examination of student outcomes; as students who do not have a deficit view of their culture or identity, or different cultures or identities, in relation to STEM subject areas would be the ultimate testament to effective Cultural Competence education in the STEM classroom.

Critique of Discourses of Power

The CRE tenet of engaging in Critique of Discourse of Power in the classroom aligns almost seamlessly with the common STEM classroom practice of problem-based learning (PBL). In books and research publications regarding STEM teaching in urban settings, STEM teaching in diverse settings, and STEM teaching for social justice, PBL is a central teaching method mentioned repeatedly as the framework and methodology provide equitable access to meaningful STEM learning to all students (Aikenhead, 2006; Barton, 2003; Tobin, Elmesky & Seiler, 2005, Yager, 2010). PBL is not a new instructional approach, but is gaining popularity in direct reference to meaningful, relevant, and equitable STEM education.

The CRE tenet of Critique of Discourse of Power involves students and teachers co-examination of societal power structures. However, it is not simply enough to examine these structures as critique for social justice involves more than simply recognition; sociopolitical action and problem-solving measures are needed as well. This means that to actualize CRE in the classroom teachers and students and teachers cannot simply recognize and discuss inequity and social justice topics - they must actively participate in actions that address these topics.

PBL has several tenets itself, which offer multiple integration points with the CRE tenet of Critique of Discourse of Power:

1. Student ownership of learning,
2. Inquiry-based,
3. Must be cross-curricular,
4. Must involve student collaboration, reflection, and self- and peer-assessment,
5. Activities must have meaning in the real-world context, and must be showcased for the community (Savery, 2015).

While the first four requirements describe many STEM classrooms, adding and actualizing the fifth describes the CRE STEM classroom. Centering an identified problem, allowing students to engage in real-world problem-solving, and then working in the context of the problem to actually be a part of solving the problem is PBL. Integrating an element of examining why this problem exists in the first place and what societal structures maintain that problem places PBL firmly in the realm of CRE.

Positive intervention results are the norm in the literature looking at PBL as a way to boost underserved student interest in STEM. Adams, Gupta, and Cotumaccio (2014) report that interest in science is influenced by a sense of belonging and that the collective work on a

common project leads to that sense of belonging. Amador and Soule (2015) highlight that a sense of ownership in the direction of the project led to increased motivation to accomplish the project, and that excitement in STEM projects could be tied to the ability to accomplish student-driven goals.

Bicer, Boedeker, Caparo, and Caparo (2015) reported that PBL in STEM classrooms increased student knowledge and understanding of academic vocabulary deemed essential for future STEM learning. Hansen and Gonzalez (2014) report that project and technology-based learning experiences correlate with higher student achievement measures on end-of-course exams for all students, including racial and ethnic minorities. Andersen and Ward (2013) suggest more awareness of the real-world connections in STEM courses may encourage more minorities to persist in STEM, and that PBL is a way to add this much-needed relevance to the classroom.

The integration of PBL with the critique of discourses of power component of CRE is exemplified by the following example. Barton (2003) describes several thematic and problem based units in *Teaching Science for Social Justice*, including detailed descriptions of creating a community garden and the integration with science standards. Students lived experiences of not having a safe and beautiful community that would be a source of personal pride served as the basis for this project - the problem that students would work to solve. Students came up with the idea of installing a community garden as a beautification project, with the student-generated idea that if the community had features like a garden for citizens to enjoy, perhaps citizens would take more pride in the community and work to further better the community.

STEM standards and practices were incorporated constantly throughout the different project phases. Students researched problems and brainstormed possible solutions. Students designed, engineered, and then built aspects of the project, including benches and signs. Students

surveyed and planned the garden, built models of their plans, and debated the pros and cons of each design before arriving on a final choice. Students participated in action necessary to locate and secure space for the garden, and finally, enacted the garden in their community. Barton (2003) provides a table of alignment with the science standards enacted (p. 113), and descriptions of the benefits to both historically marginalized students and community as a result of this problem-based learning experience.

The above-described studies and interventions show the connection between PBL, frequently used in STEM classrooms, and the Critique of Discourse of Power tenet of CRE. I now describe how the final component of CRE, Critical Reflection, fits into STEM teaching and learning.

Critical Reflection

Teacher beliefs and attitudes affect, to a great deal, how teachers implement and facilitate student learning, motivation, and achievement in their classrooms (Bryan, 2012). For STEM teachers, these beliefs come from a teacher's personal educational experience, their conceptions of science and STEM, their knowledge of their students, and their knowledge of themselves (Bryan, 2012). STEM teacher beliefs are frequently researched, as these beliefs directly impact their ability (or lack of ability) to deliver quality STEM content without fostering misconceptions (Lederman, 2007). CRE requires that teachers consistently and iteratively engage in Critical Reflection as an examination of personal and structural biases. This type of reflection is congruent with what researchers of STEM teachers' beliefs recommend as the pathway towards overcoming preconceived or misconceived notions of STEM teaching and content. Examples include:

Mansour (2008) argued that teacher beliefs need to be examined with respect to context and culture in order to understand the relationship that exists, inconsistently, between science teacher beliefs and practice in the classroom. Mansour (2008) points out that the sources of these beliefs (both about science and about science teaching) are residual from one's own science learning experiences, resulting in many science teachers who believe in the "transmission mode" of science teaching and learning (p. 29). In discussing why teachers hold these beliefs even after teacher preparation which provides a research and knowledge base in contrast to these beliefs, Mansour (2008) points out that beliefs can overshadow knowledge, and beliefs are more closely tied to behavior (such as classroom practice) than knowledge. Mansour (2008) notes: "teachers alone cannot be responsible for the quality of their classroom practices. External, contextual factors can be a barrier for teachers in putting their theories into practice. These constraints are socially constructed and can be modified, if not deconstructed and reconstituted" (p. 40).

Leback (2013) investigated how teachers' beliefs about diverse students have been shown to affect the use of widely accepted STEM teaching practices like inquiry. Leback (2013) reported that STEM teachers often have deficit views of Black and Hispanic students, and that these deficit views actually impacted a teacher's willingness to use universally accepted best teaching practices in the science classroom. Focusing on the potential to change teacher beliefs, Leback (2013) demonstrated the importance of highly structured and supported year-long teacher reflection process (which included viewing videos of lesson enactment) in changing beliefs. While Leback (2013) found that a change in teacher beliefs did not always lead to a change in classroom practice, the reflection involved was viewed as a step in the process towards enacting equity-conscious STEM teaching. Additionally, this study demonstrates just how difficult belief change is; even with this highly-supported and reflection-intense intervention for teachers, many

beliefs remained unchanged. This reiterates the CRE requirement that Critical Reflection be ongoing, as brief and inconsistent reflection have little or no impact on teachers' beliefs.

The STEM applications of Critical Reflection component of CRE is not limited to examining and restructuring STEM teacher beliefs and biases. In addition to grappling with personal beliefs and biases, STEM teachers often struggle with their own professional identities. In STEM education, the balance between content knowledge and pedagogical ability is a debated and even a legislated topic. Teacher licensure regulations outline requirements needed to achieve a *highly qualified* teacher status. State and National requirements dictate how many *highly qualified* teachers must be staffed in schools, and which subject areas must be staffed with *highly qualified* teachers. While there are political and policy suggestions that content knowledge is paramount for STEM teachers, there is pushback from educational researchers regarding the importance of pedagogy (Kahle & Woodruff, 2010).

The term Pedagogical Content Knowledge (PCK) in STEM teaching recognizes the integrated relationship of content-specific knowledge with components of pedagogical knowledge and practice expertise. Several reviews on the meaning of PCK identify five codependent domains, including the teacher's orientation towards science teaching, the teacher's science content knowledge, the teacher's knowledge and use of assessment, the teacher's knowledge of the current level of student understanding, and the teacher's knowledge and use of instructional strategies (Dreschler & Van Driel, 2008; Park & Chen, 2012; Windschitl, Thompson, & Braaten, 2011). As we can see, these domains are a combination of content knowledge and pedagogy. And while some STEM teachers balance these identities, many more find themselves more polarized along the spectrum of content expert vs. pedagogy expert (Kahle & Woodruff, 2010).

In order to bridge the identity gap from STEM expert to STEM teacher, research points to Critical Reflection as a method to facilitate this transition (Dreschler & Van Driel, 2008; Windschitl, Thompson, & Braaten, 2011). Dreschler and Van Driel (2008) noticed different reflection patterns present in teachers with different levels of PCK, while Windschitl et al. (2011) centered their research around the importance of reflection in developing PCK. Windschitl et al. (2011) used many different terms for this teacher reflection, including *analysis and collegial conversation*, *analysis of practice*, and *collegial analysis*, before settling on the term *critical friends group* (CFG) to describe the group reflective practice that they investigated. The goal of the CFG was to allow teachers to “situate their current repertoire of instruction within an explicit continuum of development, and to visualize their practice as an object of critique, evidence-based analysis, and target of ongoing refinement” (p. 1313).

Echoing the findings of Leback’s (2013) investigations on structured reflection as a way to encourage teacher belief change, Windschitl et al. (2011) report similar challenges in the reflection process as a way to impact teacher identity as professional with PCK, or practical expertise in both content and pedagogy. As with belief and bias change, teacher identity transition can be a slow and difficult process with the benefit to be enhanced by structured, meaningful, Critical Reflection. The above discussion shows how the Critical Reflection component of CRE is applicable for use by STEM educators to address both personal beliefs and biases as well as their professional and teaching identities.

Critical Reflection, however, is not limited to the teacher. This aspect of CRE also requires critical examination and reflection of all contexts of the learning environment, and should involve students as active participants in this process. Standards, assessments, curriculum, activities/experiences, videos, worksheets, texts are all subject to scrutiny. This critical

examination of support materials is essential specifically in the STEM classroom, especially in the context of the current politicization (and the resulting polarization) of science and the rise of fake news and alternative facts. The reality of current American society is that reductionist, biased, misleading, or downright fake representations of STEM topics frequently grab media attention and thus the attention of secondary students (McGrew, Ortega, Breakstone, & Wineburg, 2017). Without the critical examination and reflection required by CRE, this pseudoscience will find hold in our STEM classrooms and thus in the minds of our students.

One example of Critical Reflection of learning materials in the STEM classroom is the learning process of agnotology, which is the direct study of misinformation (Fleener-Lovitt, 2014). Both Fleener-Lovitt (2014) and Brown and Golden (2017) describe how agnotology can be a powerful tool in the secondary STEM classroom in the context of guiding students through critical examinations of misinformation about climate change. But, as scientific misinformation is not limited to climate change, this learning tool could be used in STEM classrooms regarding a variety of issues frequently misrepresented or misinterpreted in the social realm.

This example of how to integrate Critical Reflection into STEM shows this final tenet of CRE is not just limited to teacher use in secondary STEM, but also used with students to scaffold essential critical thinking and examination skills that go beyond the STEM classroom.

Conclusions

Based on overlap with several dominant themes in best practices in STEM education, STEM education theory, and equity STEM teaching, CRE is well-suited for use in the secondary STEM classroom. A representation of the applicability of CRE to the STEM classroom, as discussed in detail above, is provided in Table 1.

Table 1: Applicability of CRE to STEM Education

<u>Tenet of CRE</u>	<u>Academic Skills and Concepts</u>	<u>Cultural Competence</u>	<u>Critique of Discourse of Power</u>	<u>Critical Reflection</u>
<u>Applicability to STEM Education</u>	Mastery Teaching and Learning	Identity-respecting Teaching and Learning	Problem-Based Learning	STEM Teachers Identity and Beliefs research/ literature
<u>Examples in STEM Education</u>	Grades based on mastery of Academic Skills and Concepts, not completion of events.	Confronting negative stereotypes, understanding the dangers of deficit perspectives, understanding the connection between motivation and achievement.	Students solving a real-world problem - a problem created by power structures - embedded in science standards (Community Garden)	Recognition that pre-existing beliefs impact STEM education and intentional reflective practice is needed to overcome these beliefs, direct examination of pseudoscience.

This justification and acceptance that the tenets of CRE are compatible with STEM education research and practices leads to a current review of how, exactly, CRE is being used in STEM classrooms.

Current Literature Analysis of CRE in STEM

With the alignment of CRE with STEM teaching and learning explained, I narrow the focus to a current conception, based on research, of cultural relevance enacted in the STEM classroom. In order to respect the call for rigorous literature review techniques that integrate research methods (Boote & Beile, 2005; Lubke, Britt, Paulus, & Atkins, 2017), I conducted a qualitative analysis of current research involving culturally relevant STEM education. My methods and rationale for this analysis are described below.

In order to be included in this analysis, research studies needed to meet the following bounding criteria:

1. Published from 2014-current, and
2. Directly related to STEM education as practiced in the 6-12 classroom.

I decided to limit the studies included in this review to the years 2014 through 2017 in order to add to the conversation of culturally relevant STEM education rather than replicate previous analyses of these topics. Excellent reviews of slightly more dated research in culturally relevant STEM education include Aronson and Laughter (2016) and Morrison, Robbins, and Rose (2008).

Limiting the studies to STEM education as practiced in the 6-12 STEM classroom was a difficult decision to make, as many efforts towards culturally relevant STEM education occur outside of the school or outside of school time. In fact, research centering on inequities in STEM fields, specifically how to successfully address these documented motivation and participation gaps, often diverges along two courses of study: classroom-based intervention and the potentials of out of school time programs. Out of school time (OST) programs are popular in the research arena and are commonly praised for their short-term impact on student motivations and attitudes towards STEM fields. However, even though often designed to serve underrepresented populations in STEM, these OST programs are often fraught with their own, inherent inequities (Moore, Murphey, Bandy, & Cooper, 2014). Examples include lack of equitable access to after-school or place-based programs (access being limited to those students who have transportation during after-school hours and/or to a location other than school) as well as financial limitations (Moore et al., 2014). Additionally, Moore (2014) reports that OST programs are also not always staffed or implemented by teaching professionals.

For these reasons, in this review I focus on research that uses classroom-based practices designed to address the issues regarding inequity of STEM education. While intersections of inequalities permeate all investigations into social justice in education, I chose to eliminate the unique inequities of some OST programs. Despite the differences one would find from classroom to classroom, school to school, district to district, all classrooms have at least one thing in common: the existence of a classroom teacher. Secondary STEM teachers play an important role in motivating students to pursue STEM courses of study in higher education that lead to STEM careers. As this research centers on STEM teachers and what they enact in their classrooms, it seems logical to limit reviewed literature to research describing STEM teachers in their classroom.

With the classroom justified as my preferred context to address educational inequities in STEM education, I turn to reviewing the use of CRE in the standards-based STEM classroom. Each tenet of CRE is outlined individually below, with an explanation of its unique fit and applicability to STEM education.

To find articles for potential inclusion, I searched both ERIC/EBSCO and Google Scholar using all possible combinations of these two search criteria:

1. Culturally relevant OR Culturally responsive

AND

2. STEM Education OR Science Education OR Technology Education OR Math Education
OR Mathematics Education.

Studies identified by this search were reviewed for their applicability to the 6-12 STEM classroom. To be clear, research did not have to take place in the 6-12 STEM classroom for inclusion, but a focus on classroom-based 6-12 STEM teaching and learning needed to be

present. Thus, studies conducted exclusively in OST time, and/or studies focused solely on elementary education or higher education/teacher preparation were not included in this portion of the literature review, but are included in the section above that aligns CRE for use in STEM education.

After eliminating articles that did not meet the above bounding criteria, nine articles were identified for further summation and analysis of the current CRE conceptualization in relation to secondary STEM teaching and learning (See Table 2). These articles were coded deductively for the four tenets of CRE serving as the base categories using NVivo 11. Each of these articles is briefly reviewed below, and the collection of articles are discussed in a thematic analysis and integration of subjectivities to follow.

Current Literature Overview

Booker (2016) investigated the role of authentic pedagogy and teacher relationships with students in fostering academic achievement in math for African American girls. Booker reports that strong, personal, and respectful relationships between teacher and student lead to more motivation to achieve academically, as well as noting that making math teaching relevant to everyday life for students is a difficult yet beneficial task for teachers to undertake. However, the relevance mentioned in this study does not cross over into what might be classified as cultural relevance, showing a common missed opportunity of CRE in the classroom.

While the researchers strive to support relevant, authentic pedagogy, there is no mention of using this pedagogy to tackle real-world problems in respect to the students lived experiences, nor to model critical or sociopolitical consciousness in the classroom. The role of the teacher is largely described as one that needs to build relationships with students of Color, and to make math learning applicable to their daily lives (but without mentioning how culture plays a role in

Table 2: Articles Selected for current literature review and analysis

<u>Authors</u>	<u>Year</u>	<u>Title</u>	<u>Journal</u>
Booker	2016	Belongingness and Pedagogy: Engaging African American Girls in Middle School Mathematics.	Youth & Society
Brown, Mangram, Sun, Cross, and Raab	2017	Representing racial identity: Identity, race, the construction of the African American STEM students.	Urban Education
Fasasi	2017	Effects of ethnoscience instruction, school location, and parental educational status on learners' attitude towards science.	International Journal of Science Education
Gao and Wang	2016	Do variations of science teaching approaches make difference in shaping student content and problem solving achievement across different racial/ethnic groups?	International Journal of Environmental and Science Education
Goodhew and Robertson	2017	Exploring the role of content knowledge in responsive teaching	Physical Review Physics Education Research
Gurgel, Pietrocola, and Watnabe	2016	The role of cultural identity as a learning factor in physics: a discussion through the role of science in Brazil.	Cultural Studies of Science Education
Gonzalez-Espada, Llerandi-Roman, Fortis-Santiago, Guerrero-Medina, Ortiz-Vega, Feliu-Mojer, and Colon-Ramos	2014	Impact of Culturally Relevant Contextualized Activities on Elementary and Middle School Students' Perceptions of Science: An exploratory study.	International Journal of Science Education
Stevens, Andrade, and Page	2016	Motivating Young Native American Students to Pursue STEM Learning Through a Culturally Relevant Science Program	Journal of Science Education and Technology
Scott, Sheridan, and Clark	2014	Culturally responsive computing: a theory revisited	Learning, Media and Technology

this endeavor). Thus, while the recommendations are certainly beneficial to the math classroom learning environment, they fall short of meeting the requirements of true CRE.

Brown, Mangram, Sun, Cross, and Raab (2017) looked at one school's attempts to foster African American male students' academic success in STEM by pointedly and specifically using various culturally-inspired representations and affirmations. This study recognizes the role of identity learning in motivations to persist in STEM, and that negative stereotypes along with the focus on achievement of White scientists to the exclusion of African Americans can lead to a negative STEM identity in young African American men. This study is an example of the overlap between Cultural Competence and academic achievement, as, in this case, the school hypothesized that increased Cultural Competence at the school level would lead to higher STEM academic achievement for African American male students.

However, while this study described the various methods and initiatives, at both the building and classroom level, enacted to foster this Cultural Competence through identity learning, the study did not provide any evidence or discussion on if the hypothesis that these methods would (or did) parlay into Academic Skills and Concepts. And yet again, the component of critiquing the powers that subverted African American science identity were missing; instead a positive African American STEM agenda pushed forward without recognition of why this had to be a focus of the school in the first place.

Also, the school's program was clearly delineated for teachers - in almost checklist fashion of what African-American inventors they would discuss and what HBCU's pennants they would display in the hallways; void of any evidence of Critical Reflection on the part of the teachers to support and further this school-wide initiative. Again, this description of promoting

cultural identity, racial identity, and achievement identity is certainly to be applauded, it falls short of meeting multiple requirements of CRE.

Fasasi (2017) looked at the influence of ethnoscience instruction (along with the additional variables of school location and obtained education level of parents) on fostering students' motivations to persist and achieve in science education. Ethnoscience instruction is defined as "instructional approach that systematically accesses and assesses the prior cultural beliefs and ideas of learners that are related to the science concept being taught to ensure a better understanding of the concept" (p. 551). This study indeed found that "making the learning and the teaching of the topics more relevant to students' lives helps them see the value of science and in turn motivates them to develop a better attitude towards science and science education" (p. 558). While this study, too, asserted that increased motivations and attitudes towards science would lead to increased science academic achievement, no data for this study looked at academic achievement of students by any measure. So, again while commendable, we see this research effort just looks at one aspect of CRE (ethnoscience instruction being described as quite similar to culturally competent instruction) rather than the outcomes that may occur with an overlap of multiple, of not all, tenets of CRE.

Gao and Wang (2016) bring up an unpopular position among many science education researchers in their findings - that constructivist, inquiry-based learning might not be the most effective teaching model for equitable STEM instruction. They suggest that constructivist, inquiry-based learning is incompatible with culturally relevant education as "not all students come from cultural backgrounds that encourage inquiry practices" (p. 5407). This position seems to show a disconnect between learning theory and cultural relevance in the classroom, as well as a misunderstanding of how CRE respects and honors culture in the classroom. After all, letting

any single specific culture dictate the classroom norms is precisely the underlying need for CRE in our society, and is not a practice promoted by CRE.

Instead of explaining this study further, I let this stand as an example of the reductionist misunderstanding of CRE and how these misunderstandings (in the research realm) can lead to questionable interpretations of data. However, I will agree with the researcher's assertion that "what a teacher does in the classroom is only one part" of the larger system that influences student outcomes. This is exactly what CRE attempts to describe; not a check-list for teachers, but the larger system needed for equitable and accessible STEM education for all students.

Goodhew and Robertson (2015) asserted that teacher content knowledge is an essential component of responsive teaching, as in-depth and intricate content knowledge is required in order for teacher to fully conceptualize how to relate content to students. Responsive teaching is described as teachers recognizing that "students come to classrooms with a wealth of productive knowledge and experience" that teachers must strive to understand in order to relate content to student existing knowledge (p. 1). Again, while not contesting the benefits of relating STEM content to students lived experiences, this study does not focus on using culture as a frame or influence for these lived experiences. Also, again, lacking are elements of academic achievement, Critique of Discourse of Power, and Critical Reflection. Relevance is a wonderful item to strive for in the STEM classroom, but should not (alone) be misconstrued as CRE.

Gurgel, Pietrocola, and Watanabe (2016) used an intervention study to investigate the role of identity learning on Brazilian students' concepts of physical science and cultural identity, and reported positive student identity outcomes. Gurgel et al. (2016) start by clearly critiquing the societal powers that keep learning about Brazilian scientists out of the mainstream Brazilian science classroom, and then detailing a lesson that shows how to re-integrate culture into the

science classroom in a way that is meaningful and relevant to students plus supports the creation of positive culture-science identity.

While power structures and inequities are critiqued as an underlying motivation for this research, the lesson plan detailed does not bring this issue directly to students. Yet, in discussions, students caught on to the fact that something had kept this presentation of knowledge from them previously, and “questioned the social dimensions involved in the possibilities of scientific development in Brazil” (p. 368). Additionally, future activities were designed to look into these societal issues more and brainstorm action items to address them.

This is one of the only studies in this examination that references or addresses all tenets of CRE. Lack of examples are often listed as an impediment to implementation of CRE in the STEM classroom, and this study provides one such example. A tension with examples of CRE is that they are usually quite limited in actionability based on the exact cultural and content context. For example, this study would be useful to physical science teachers in Brazil. But, due to differences in culture and content, would not necessarily be actionable in a different culture and/or with a different subject area or grade span. So while this is an excellent example of enacting all aspects of CRE, this study lacks generalizability to other cultures and subject areas.

Gonzalez-Espada, Llerandi-Roman, Fortis-Santiago, Guerrero-Medina, Ortiz-Vega, Feliu-Mojer, and Colon-Ramos (2014) describe the overlap of contextual/situated learning and culturally relevant pedagogy in examining Puerto-Rican students’ perceptions and motivations towards science, and they report little relationship between these variables. Once again, however, I would caution against acceptance of the interpretation of data without a close look at the researcher's’ conceptions of the variables. Culturally relevant pedagogy seems to be misunderstood or misinterpreted in this study. Gonzales-Espada et al. (2014) define CRP as

“respecting student thinking, using students’ prior knowledge, using active learning, empowering students, linking the classroom and the community, and valuing the students’ native language” (p. 187), which itself is a representative if not fully descriptive explanation.

However, in the intervention described, the element of cultural relevance is reduced to “the use of symbols, scenes, and concepts that are uniquely Puerto Rican and/or refer to Puerto Rican characters, locations, and communities in which the stories are based” (p. 189) with no explanation of how the remaining tenets of CRP are addressed in the methodology of the study. Additionally, based on ceiling results, researchers report that “participants had a generally good perception of science to start with,” which begs the question of why this population would be chosen to investigate the intervention’s impact on perception of science.

Once again, I recognize the benefits of the interventions of this study, but I must point out that this study is not representative of all aspects of CRP/CRE, and also that this study exemplifies that a disconnect between theory and practice of CRP/CRE exists in the research world, as well as the practitioner realm. It is an emerging theme to cite tenets of CRE in the introduction or rationale of a study, but not fully implement or conceptualize these in the methodology or intervention phase.

Stevens, Andrade, and Page (2016) conducted a long-term investigation of a hybrid in-school and out-of-school time STEM program designed to foster STEM motivations in Native American students. This research chronicles the “development, delivery, and outcomes of a culturally driven science, technology, engineering, mathematics (STEM) program” (p. 947). The conception of culturally driven STEM education was based on the ideas that students have valuable funds of knowledge relatable and relevant to STEM content. The development of this program required Critical Reflection from the teachers, the delivery required Cultural

Competence, and the fact that this study discussed student outcomes shows a dedication to the academic skills component of CRE. The fact that this type of intervention exists in schools serving Native American students speaks to the Critique of Discourse of Power; however, to fully embrace CRE this aspect would need to be more apparent and explicit to students participating in the intervention, not just an underlying subtext.

Research on STEM topics is often, itself, reduced to science or math content areas. In a break from this tradition, Scott, Sheridan, and Clark (2014) provided a framework for culturally responsive computing. This description of teaching technological skills is designed to be race, ethnicity, and gender inclusive, and is based on a combination of Ladson-Billing's CRP and Gay's cultural responsiveness. Culturally responsive computing is described as motivating students with standards-based STEM learning experiences that bridge the gap between culture and STEM identity by providing a "deeper understanding of heritage and vernacular culture, empowerment for social critique, and appreciation for cultural diversity" (Scott et al., 2014, p. 415). Scott goes on to explain the application of culturally responsive computing in both the researcher and practitioner realms, as well as the pathway towards creating culturally relevant computing programs, with specific emphasis on the process of Critical Reflection necessary for both researchers and educators.

In an additional alignment with the tenets of CRE, Scott et al. (2014) repeatedly discussed culturally relevant computing as a program, rather than any one intervention, or lesson plan, or investigation. This recognition that CRE in STEM involves the overlap of all tenets of CRE, instead of one or two components used and investigated in isolation, places this study as an exemplar of recent research in culturally relevant STEM education.

Current Literature Review and Analysis

Following reviewing the identified articles for compatibility with the bounding criteria, the studies were deductively coded (Gilgun, 2005) using NVivo 11. The four tenets of CRE served as my initial categories for this project, and the themes that emerged from this coding are discussed individually. Overlap in codes was not uncommon, and these relationships are discussed in this analysis as well. Explanations of this coding are presented below, by category. Graphic representation of this coding scheme are found in Appendix A. A final discussion of the integration of my experiences and subjectivities follows the thematic analysis to create a conceptual model of the current state of CRE in STEM classrooms.

Thematic Review: Cultural Competence

The largest group of codes related to the Cultural Competence tenet of CRE, and the largest group of codes within the Cultural Competence category related to identity learning. Multiple studies emphasized identity learning as a way to foster Cultural Competence in education. Multiple pathways towards supporting identity learning were identified across the studies, including the use of affirmations, role models, and school environment.

Several codes within identity learning were identified, including academic identity, cultural identity, and racial identity. Academic identity codes often overlapped with the codes found in the Academic Skills and Concepts category, showing a relationship between these two tenets of CRE.

In addition to identity learning, specific pedagogical practices that fall into the realm of Cultural Competence were identified, such as “ethnoscience instruction” (Fasasi, 2017) and “authentic pedagogy” (Booker & Lim, 2016). These both described a way to approach STEM education that values culture and uses culture to relate content area learning to students. This

code also showed a somewhat reductionist view of Cultural Competence in some instances.

Although the researchers often discussed and referenced cultural relevance, in multiple instances what was actually being stressed was just basic relevance (without regard to culture). This is an important distinction, as although striving to make content area learning relevant is certainly important, relevance alone does not equate to cultural relevance or Cultural Competence.

Thematic Review: Academic Skills and Concepts

The category of Academic Skills and Concepts was the second-largest category of codes behind Cultural Competence, with all references analyzed making some form of reference to the importance of fostering and supporting academic outcomes for students. As previously mentioned, many of these were in the realm of scaffolding the development of an academic identity, to be co-constructed with the other identities that students assume as they grow and develop.

Attainment of an academic identity was repeatedly referenced as a precursor for academic success and motivations to persist in STEM education. However, this category also shows disagreement on how to measure academic achievement in the context of CRE. None of the studies used grades or test scores as an indicator of academic skills, instead focusing on measuring attitudes towards academics as an indicator of academic success. Grades or test scores are certainly not an all-inclusive measurement of student Academic Skills and Concepts, but they are one measure of such, and an important measure in the current context of public education. Even with this focus on attitudes and motivations as an academic success indicator, most of the studies did not use any measure for attitudes and motivations, instead just asserting that their interventions/methods/practices should lead to increased attitudes and motivations.

Thematic Review: Critical Reflection and Critique of Discourse of Power

Although these two tenets of CRE were two distinct categories, they are discussed together here due to the absence of codes that were identified. CRE calls for teachers and students to co-participate in critiques of discourses of power and Critical Reflections, yet the recent, relevant literature on the topic seems largely void of these tenets. When Critique of Discourse of Power was identified as a code, most often this was found in the literature review, background information, or theoretical framework section, with no evidence of how to enact in the classroom.

While the importance of teachers engaging in Critical Reflection as a self- and teaching-practice-improvement technique, only one study described students engaging in a Critical Reflection activity (Scott et al., 2014). In summation, when Critical Reflections and Critique of Discourse of Power were present in this review, they took place outside of the relationship with students and separate from instructional activities involving students. This shows a void in the application of CRE to STEM classrooms and an area to focus further research on the topic. Using the above reviews of the current state of CRE in STEM classrooms, the overarching, prominent characteristics are presented in Table 3:

Implications: Why the Misunderstandings and Underuse of CRE?

The above analysis of current literature on culturally relevant STEM education, while showing many excellent examples of portions of CRE in STEM education, more dominantly shows that CRE is misunderstood and often underutilized in STEM classrooms. While the potential benefits of CRE are well researched and documented, so are the struggles and tensions of teachers attempting to enact CRE in the classroom. As with any practice identified to be valuable and effective, but not widely used, theories and blame emerge in an attempt to explain

the lack of use. Several conceptualizations of the lack of use of culturally relevant education are presented below.

Table 3: Areas of Refinement and Reinforcement in Current Culturally Relevant STEM Research

<u>Areas of Reinforcement</u>	<u>Areas of Refinement</u>
CRE remains a topic of study in the realm of applicability to the STEM classroom, but...	...studies that model or explain the classroom use of <i>all</i> tenets of CRE are few and far between.
Examples of CRE in the STEM classroom do exist, but...	...these are likely to be specific to the culture and content for which they were created and not universally applicable to most STEM teachers looking for guidance.
Cultural Competence is the tenet of CRE most likely to be utilized in the STEM classroom, but...	...misunderstandings regarding Cultural Competence abound. (portraying Cultural Competence as the entirety of CRE, portraying relevance as cultural relevance)
Academic Skills and Concepts are taking on a more prominent role in CRE research, but...	...absence of measures of Academic Skills and Concepts provide an area for improvement.
Critical Reflection and Critique of Discourse of Power are often accomplished in the research rationale, but...	... Critique of Discourse of Power and Critical Reflection are rarely incorporated into classroom practice involving students.

Sleeter (2012) discussed three main themes in the examination of the lack of use of CRE: misconceptions of CRE, research disconnects with student achievement, and pervasive societal Whiteness. Misconceptions identified by Sleeter (2012) include not recognizing the role of Academic Skills and Concepts in CRE, celebrating and understanding culture but not expressly linking this to content, infrequent and inconsistent enactment of the tenets of CRE, and reducing CRE to a list of steps or activities to conduct in the classroom.

Additionally, Sleeter (2012) found that teachers who did utilize culturally relevant practices often stopped short of Critical Reflections and critique of discourses of power,

explaining that teachers maintain “silence about the conditions of racism and other forms of oppression that underlie achievement gaps and alienation from school, assuming that attending to culture alone will bring about equity” (p. 571). Sleeter (2012) also argues that in the context of our policy-driven educational system, more research would be needed to link CRE with the accepted measures of student achievement in order for the practice to gain footing in classrooms. And finally, Sleeter (2012) points out the “political backlash” of daring to suggest that we center education on more than just dominant culture and paradigms, and the view of cultural relevance as threatening to American values (p. 577).

Fasching-Varner and Seriki (2012) similarly identify several reasons why CRP struggles to find a place in classrooms. Among the challenges identified for implementing CRP in classrooms are the pervasive Whiteness of teaching culture, the sociopolitical and sociocultural pressures of the school community, as well as what Fasching-Varner and Seriki (2012) identify as “the disconnect between the theory of CRP and how teachers articulate what it is that they actually believe to be culturally relevant” (p. 2). They also identify the emergence of *Free and Reduced Pedagogy* as a one-size-fits-all replacement for, and misunderstanding of, individualized Cultural Competence.

Educators displaying *Free and Reduced Pedagogy* tend to “use explicitly politically correct, progressive, and evolved narratives to speak about difference while simultaneously inserting *buts* and *wells* that reveal more implicit perspectives on those whom teachers see as different from them” (Fasching-Varner & Seriki, 2012, p. 3). Additionally depressing is the observation that teachers with “explicit commitments to CRP and social justice education often find themselves standing alone” in trying to both highlight the importance of and implement CRP in the classroom or school, and these solo endeavors stand little chance of success

(Fasching-Varner & Seriki, 2012, p. 4). While being an agent for change in a school is a characteristic of CRE, it is not one that many educators are prepared to enact alone, especially as new or beginning teachers. The lack of allies becomes an additional reason for infrequent classroom application of CRE.

Research specific to culturally relevant STEM education reiterates the presence of misunderstandings regarding both theory and implementation in the classroom. In a practitioner-based study of culturally relevant math instruction, Ukpokodu (2011) points out a lack of identified culturally relevant practices as an impediment to teacher implementation in the classroom. Ukpokodu (2011) quotes teachers participating in his study as stating, “We do not know what culturally responsive teaching in mathematics looks like,” “uninformed-never seen in it action,” and even “never heard of it” (p. 50). Ignorance of the theory itself along with not knowing how the theory manifests itself in the classroom seems evident in these statements and could be a reason teachers are hesitant or unable to employ culturally relevant STEM education.

Even when teachers were given direct instruction on culturally relevant STEM education, misconceptions about the enactment persist. In a practitioner-based study of culturally relevant science teaching, Nam, Roehrig, Kern, and Reynolds (2013) explored what happened when teachers were given in-service training on how to teach concepts of climate change to American Indian students using several aspects of traditional culture, history, and beliefs. Even following this teacher training, Nam et al. (2013) found “that teachers’ views of culturally relevant science teaching vary according to their perceptions and knowledge of traditional science content and culturally relevant science teaching strategies” (p. 163). This recognition that teacher perceptions and preconceived notions impact their ability to actualize CRE, even when given professional

development on the topic, supports the previously-discussed notion that teachers' beliefs and preconceptions impact their inclinations towards CRE.

Role of Teacher Education

With so many examples of teachers unprepared, either pedagogically or in the realm of their attitudes and beliefs, to enact CRE in their classrooms, the conversation organically shifts to how teacher education programs are (or are not) preparing future teachers to appropriately and equitably teach all students in their increasingly diverse student populations.

In *Crossing Over to Canaan*, Ladson-Billings (2001) likens teacher education to a road trip, calling the “road to teaching is a long, boring highway of sameness” punctuated by “the toll booths that are apparent in the myriad of competency tests, content examinations, and performance evaluations being foisted on those who would be teachers” (p. 2). Ladson-Billings argues that this context for preparing teachers often ignores the ever-changing cultural, social, and political contexts of preparing teachers; many teacher educators have never experienced teaching in the same context as their students will. Additionally, the Whiteness of teacher educators who, themselves, have neither experienced nor actualized CRE, means that “teacher educators have trouble leading prospective teachers to a place that they themselves have not been” (Ladson-Billings, 2001, p. 6). These observations of the reality of many teacher education programs certainly play a role in the lack of teachers entering the workforce prepared to enact CRE.

Taking a more critical stance, Hayes and Juarez (2012) placed the blame squarely at the feet of teacher education programs for the lack of CRE enacted in schools. As Ladson-Billings (2017) asked *How can we develop culturally competent students if our teachers are culturally*

incompetent?, Hayes and Juarez (2012) repeatedly point out that the culturally incompetent teachers are a product of culturally incompetent teacher education programs.

Hayes and Juarez (2012) outlined several action items for teacher preparation programs in order to address what they see as the perpetual preparation of teachers who are unprepared to teach the diverse students and cultures that they will undoubtedly find in their classrooms:

1. To recognize the pervasiveness and endemic nature of racism in society,
2. To abandon notions of Color-blindness as acceptable approaches to race relations,
3. The acceptance of inequities in society that merit alone cannot overcome, and
4. To explicitly address Whiteness as property, given the dominantly White teaching force, so that transitions can be made towards social justice in the classroom.

Choosing to forgo the deficit view of teacher education, Mensah (2011) describes the potential benefits of a teacher education program that centers CRE and actively supports all teacher education candidates to enact CRE. In a study of three student teacher's efforts to create late elementary science lessons rooted in CRP, Mensah (2011) presents what are identified as exemplars of culturally relevant science teaching, planning, and reflection at the same time as explaining the role that a teacher education program plays in providing the environment where such lesson plans can be created. Mensah (2011) also highlights the role of the teacher education program in encouraging reflective practice and collaboration, which allowed the exemplars to enact CRE in their classrooms.

Wallace and Brand (2012) iterated the need for teacher education to adequately prepare candidates for teaching in diverse settings, and point out that in an effort to do this, many teacher education programs offer a one-size-fits-all multicultural education or urban education course. Wallace and Brand (2012) caution against this approach, noting that while these types of courses

have benefits, they alone cannot “lead to the kind of awareness that supports the constructive management of sociocultural factors influencing daily interactions occurring in the classroom” (p. 346). These courses often focus on strategies for teaching in diverse classrooms, and even concepts like building relationships with students and cultivating a classroom environment of inclusiveness, but the aspect of confronting and/or challenging personal bias is often left out. Wallace and Brand (2012) argue that this critical examination of self is essential to the learning pathway towards becoming a culturally relevant educator, and that this practice needs to be taught and modeled at the teacher preparation program.

With an approach that marries some of the sentiments of Hayes and Juarez (2012) with the role of teacher beliefs, reflection, and responsibility, Fasching-Varner and Seriki (2012) issue a directive for teacher education programs to center and focus “each and every course that candidates take” on social justice and the theory informing CRE (p. 4). Additionally, Fasching-Varner and Seriki (2012) call for teacher homework that focuses on self-awareness and self-improvement, specifically asking teachers to “critically analyze the nature of how personal narratives are embedded reflections of identity privilege” (p. 4). The idea that understanding identity and self-reflection is important to CRE should be no surprise those aware of the tenets of CRE, however the centrality of importance of understanding one’s own identity, in addition to the importance of attempting to understand the identity of others, is often challenging.

Thus, in order to support the enactment of CRE in classrooms, Fasching-Varner and Seriki (2012) recommend the following:

1. The call for teacher education programs to eradicate the stand-alone aspects of trying to implement CRE by creating pressure to implement CRE as the accepted classroom norm across grade and subject areas, and

2. The importance of understanding one's own identity in order to recognize and overcome one's preconceived notions and biases to become an effective teacher who implements CRE.

Summary Conclusions

The topic of why CRE is not widely used in the classroom setting and what to do to improve the possibility of enactment is circuitous. In the preservice teacher realm, the cycle appears to start with the lived experiences of the predominantly White teaching force, the missed opportunity to disrupt and reevaluate these implicit biases prior to unleashing these teachers upon their increasingly diverse STEM classrooms. Once in the classroom, the in-service STEM teacher's obstacles to implementation of CRE include misunderstandings or lack of conception of what CRE would look like in their classroom, lack of a support system among peers in their school, and the idea that non-negotiable job requirements like content area standards and standardized testing take precedence over (and are not congruent with) CRE. All of these factors stand in the way of CRE implementation.

Additionally, lack of evidence that in-service trainings are effective, combined with the prevalence nonscientific in-service trainings that perpetuate deficit stereotypes of students rather than focus in examination of teachers' implicit barriers to CRE, leave few interventions available to teachers once they reach the classroom. With the lack of evidence of effective support for in-service teachers, the theme emerges that all of these issues must be addressed in the teacher education piece of the potential culturally relevant STEM educator's experience. STEM teachers not practicing CRE in the classroom provide the model educational experiences for the next generation of prospective STEM teachers, perpetuating the cycle.

The focus on teacher education as the main location and situation to disrupt this cycle might be an unfair assessment based on both the enormity of lived experiences the prospective teacher will encounter both pre- and post-teacher education, and the relative short amount of time spent in teacher education when taken in context with these external experiences. The fact remains, however, that the cycle must either be disrupted at some point, or it will continue with the same results we see currently. As the results we see currently are the unacceptable marginalization of Black and Hispanic STEM students, this research actively looks for the best pathway towards cycle disruption. This research multiple influences in relation to CRE, including but not limited to teacher education, in order to identify specific recommendations for improvement based on these influences. In order to investigate this complex issue, I engaged in a qualitative critical comparative case study methodology, informed by the theory that supports CRE. The full explanation of this theoretical framework and methodology follows in Chapter 3.

Chapter 3: Methodology

Research on the multiple influences on the learning progressions of teachers towards or away from culturally relevant STEM education requires the acceptance of culturally relevant education as a theoretical framework that has both the potential to address the persistent inequities in STEM education, and is applicable for use in the STEM classroom. Accordingly, I now discuss the underlying theoretical foundations of CRE prior to describing the proposed research methods.

Theoretical Framework of CRE

This proposed research centers on the knowledge that STEM fields struggle with persistent educational inequities. The critical stance is thus needed when using CRE as the theoretical framework for this research, specifically by calling attention to culturally and racially-based oppressions and inequalities to advocate for change. The ontology of this research is actively influenced by many of my experiences. My personal experiences as a non-native resident of the racially stressed and divided south, coupled with my teaching experiences in a school with marked achievement gaps between White students and students of Color greatly influenced my interest in utilizing CRE as a way to improve equity in the classroom and access to content knowledge for all learners. Thus my ontological perspective on this study includes a recognition of the existence of racism and classism involving culture, a recognition in differences in learning among different cultures in the American public school setting, as well as an insistence for change and improvement in this area.

This interpretivist ontology is closely related to an also interpretivist epistemology in this study. Epistemology looks at the nature of knowledge, attempting to answer questions such as “what is knowledge?” “how do we know what we know?” and “what convinces us that

something is true?” (Rossman & Rallis, 2012, p.7). This study recognizes that there are epistemological differences present as a part of larger cultural differences. CRE focuses on utilizing and even exploiting these recognized differences to best support learning for all students. However, as a result of the previously discussed obstacles to implementing CRE in the STEM classroom setting, these differences often go unacknowledged or unrecognized. This study embraces the diversity of epistemological perspectives and uses these differences as an underlying assumption to the theories that inform this research. As CRE has four main principles (Academic Skills and Concepts, Cultural Competence, Critique of Discourse of Power, and Critical Reflection) the theoretical framework of this study will be explained in accordance to these bedrocks of CRE.

Academic Skills and Concepts and Cultural Competence

Ladson-Billings (1995) states that “culturally relevant pedagogy must provide a way for students to maintain their cultural integrity while succeeding academically” (p. 476). The underlying theory supporting the idea that students must experience academic success in an environment that supports the development of their Cultural Competence can be traced back to idea of *cultural capital* described by Bourdieu (Dimitriadis & Kamberlis, 2006). Bourdieu describes economic and social capital as being the methods of establishing ruling and oppressed classes, but also recognizes and describes cultural capital (both embodied culture and the products or objects of culture) as an entity that should be valued in society (Dimitriadis & Kamberlis, 2006).

Freire (1970) expands on the importance of both culture and academic success in his writings on education. One famous example is Freire’s (1970) successful work teaching agricultural workers to read in Brazil. Instead of expecting these workers to conform to the

norms of traditional schooling and education, which Freire called the “banking model of education,” Freire (1970) instead taught within the culture of the workers and reportedly successfully brought literacy into their lives in a short period of time. As important tenets of CRE, Ladson-Billing’s descriptions that academic success and Cultural Competence can and must be co-experienced by students of Color draws heavily from these works from Bourdieu and Freire.

Critical Reflection and Critique of Discourses of Power

Ladson-Billings (1995) states that “not only must teachers encourage academic success and Cultural Competence, they must help students to recognize, understand, and critique current social inequities” (p. 476). These aspects of CRE are strongly rooted in Critical Race Theory (CRT). Ladson-Billings (1998) explained that CRT in education relies on the following main ideas: that racism is normal in American society and a noted critique of liberalism that has failed to address issues of race on many societal levels.

Racism in American Society. CRT acknowledges that racism is “so enmeshed in the fabric of our social order, it appears both normal and natural to people in this culture” (Ladson-Billings, 1998, p.11). This concept derives from the works of Bell (1992) which describe racism as not only a normal aspect of American life, but also a permanent aspect. Additionally, this existence and permanence of a racial society also stems from Tatum’s (1997) observations about the visual nature of race and its role in racial development: “The parts of our identity that do capture our attention are those that other people notice, and that reflect back to us” (p. 21).

This recognition of racism and its importance in American society requires an outright rejection of “race-neutral” or “Colorblind” policies or approaches, as accepting such approaches would “devalue the experiences and realities of students of Color by denying that race

preferences and racism exists” (Brown-Jeffy & Cooper, p.73). Additionally, the tendency of policy-makers and educators alike to conflate race with intersectional but non-synonymous terms like socioeconomic status or economically disadvantaged must be acknowledged and addressed (Malcom, 2013). These terms, when used as proxies, do not recognize the persistence and permanence of racism in America.

Critique of Liberalism. The next principle of CRT informing this research involves a criticism of liberalism, including the notion of “interest-convergence” (Bell, 1980, p. 94; Ladson-Billings, 1998, p.12). Interest-convergence is the observation that situations tend to improve for the oppressed race or class only if the improvement also benefits the oppressor. Bell (1980) argued that the *Brown vs. Board of Education* decision, which ended segregation in public schools, was less about making education equitable and accessible to students of all races and more of a public relations move by the United States government in their determination to gain allies in the fight to end the spread of communism. In addition to interest-convergence, much of the critique of liberalism in CRT centers around the ineffectiveness of the American civil rights movement to address racial issues in a timely manner.

This principle of CRT draws heavily from the Gramscian idea of *hegemony* – that those who are oppressed are complicit in their oppression and that the oppressors of society promote a *slow change* process rather than a swift or radical change process (Dimitriadis & Kamberlis, 2006). Referring back to the *Brown vs. Board of Education* decision in 1954 demonstrates this *slow change*, as many schools are still racially segregated, if not by law then by de facto districting, and often times schools consisting of largely of Black and Hispanic students are considered *high-needs* schools which provide inferior learning environments than other schools (Hannah-Jones, 2014). Alternatively, these so-called *high-needs* schools are often reclaimed or

co-opted into urban STEM centers, and then opened up to out-of-district and often White student enrollment; this process in itself being an example of interest convergence (Bullock, 2017).

This research respects the presence and permanence of racism in American society as well as recognizes the failures of many policies and practices aimed to rectify this. This research also specifically focuses on the presence of persistent inequities in STEM education, and that the disproportionately White teaching force is a factor to these inequities; if not a direct contributing factor than a passive factor allowing the status-quo to proceed undisrupted.

I maintain that a review of the existing research shows that secondary STEM teachers play a unique and powerful role in motivating students to persist in STEM education and careers, but that data shows us White students are motivated towards these STEM career pathways at disproportionately high percentages.

This study relies on CRE as a way to effectively teach and motivate more students of Color towards STEM fields, but also recognizes that there are many stumbling blocks to overcome in the pathway towards enacting CRE. Additionally, this study recognizes that there is no one factor that determines a STEM teacher's inclinations towards or away from becoming a culturally relevant STEM educator. A combination of all of the above contributing factors leads me to my central research question:

- What are the major influences that shape an educator into a practitioner or non-practitioner of culturally relevant STEM teaching?

The research methods used to address this question are explained below.

Research Design

I conducted a qualitative critical comparative case study to investigate the learning progressions of teachers in relation to culturally relevant STEM education. Case studies are

examinations of specific examples with the goal of seeking to understand beyond the cases being explored (Baxter & Jack, 2008; Rossman & Rallis, 2012). The goal of case study research is to provide an accurate and detailed description of the phenomenon being investigated (Flick, 2014). In this research, the cases I investigated are the inclinations in relation to CRE in secondary STEM teachers. This research was designed specifically to describe and explore the recognized impact of multiple influences that have impacted each participant's particular learning trajectory.

Critical case studies require a theoretical framework that recognizes societal oppressions and inequalities (Rossman & Rallis, 2012). The theoretical framework of this study is clearly in the critical realm and recognizes that societal inequities are also represented in secondary STEM education. My focus is particularly critical of the correlation between a White-dominated teaching force and Black and Hispanic students being less motivated to pursue STEM education than White students. Critical case studies also look to explain factors into the status quo as a method to better understand how to disrupt the accepted paradigm (Rossman & Rallis, 2012). The status quo involved in this research is the underuse, or non-use, of culturally relevant STEM education as a mechanism to provide equitable and motivational STEM education for all students.

Comparative case studies look at multiple cases with a focus on a particular portion or phenomenon of importance to the research topic (Flick, 2014; Merriam, 1998; Yazan, 2015). Instead of providing complete details and descriptors on all aspects of each case, just the parts of the case needed to explore the research question are examined. The subject of comparison for this study is the learning pathways of teachers towards or away from enacting culturally relevant STEM education, thus aspects of the cases that are relevant to race, culture, social justice, and equity, as well as relevant background experiences and current contextual experiences, are

explored and discussed as a part of this study. This topic indeed has multiple influences to explore, but data collection with research participants will aim to collect information directly related to the teacher's attitudes, inclinations, motivations, and experiences with culturally relevant STEM education.

Research Participants

Given the focus of my research topic, research participants are all current secondary (grades 6-12) teachers of a STEM subject or subjects. As this research looks to describe multiple influences in relation to culturally relevant STEM education, this includes looking into pathways both towards and away from culturally relevant STEM teaching. Thus, pre-existing inclinations towards CRE, or previous education or implementations of CRE, are not mandated characteristic for research participants to have.

Comparative case studies often employ purposive sampling in order to ensure that the cases include the diverse perspectives needed for a comparison (Flick, 2014). As comparative case studies look to provide breadth of perspectives, minimal additional bounding criteria will be placed upon potential research participants other than the requirement that they are current secondary STEM teachers. The one additional bounding criteria placed upon interview participation is in relation to my use of purposive sampling through personal social media accounts sharing. I have social media connections with multiple STEM teachers, some of which I have classroom experience with (either during my own teacher education experience, or due to my mentoring responsibilities as a classroom teacher). To effectively remove researcher bias and preconceived notions of classroom CRE ability, I excluded STEM teachers from interview participation if I had observed their classroom practice or co-taught with them.

To ensure that multiple learning progressions are represented, as well as to help ensure trustworthiness of the data collected, I used purposive sampling to select research participants as determined by the survey instrument stage of data collection. Information regarding the participant's background with, and inclinations towards, CRE were collected via survey data. Based on this data I selected and built a comparative case that consists of STEM educators who have a variety of backgrounds in relation to CRE in STEM as well as a variety of inclinations in relation to enacting CRE in their own STEM classrooms. Given this research used human subjects as participants, IRB approval was obtained prior to the collection of data.

Data Collection

Data collection occurred in three stages; the first stage of data collection was through a survey instrument shared via social media, followed by collection of publically-available data in relation to the respondents to the survey and their teaching context, and finally data was collected through semi-structured interviews with individuals selected through the criteria described above to be members of the comparative cases for critical analysis.

Survey Instrument. In order to gather data necessary to make purposive and intentional sampling decisions and ensure diversity of learning progressions of my research participants, my first data collection tool was a modified School Climate for Diversity (Brown, 2017; Byrd, 2016; Byrd, 2017) scale. The School Climate for Diversity scale was created and validated by Byrd (2016, 2017, 2018) for use in evaluating high school students' perceptions of the cultural relevance of their own learning environments. Following communication with the creator, I modified this scale to be applicable to evaluating teacher's perceptions of cultural relevance in their former learning environments and their current teaching environment. My modified version

of this scale is available in Appendix B, and my efforts towards ensuring trustworthiness of this modified instrument are discussed below.

I shared this survey via my personal social media accounts. The survey data was used to select a diverse group of research participants, reflective of both experiences with culturally relevant STEM education, and inclinations in relation to culturally relevant STEM education. Combined with the mining of publically-available data, the survey responses were used to create descriptions of each case and craft questions for the main data collection phase: semi-structured interviews.

Survey instrument trustworthiness: Prior to conducting this study, I conducted a pilot study to evaluate the trustworthiness of the adaptations made this scale in order to adapt the scale for use with in-service STEM teachers. The main types of validity I addressed were content/face validity and predictive validity. In order to address content/face validity, I first asked a team of STEM teacher and Doctoral candidate colleagues to complete the scale and provide comments regarding the clarity and readability. Next I asked for their own interpretations of scale questions and compared these with the intent of the scale as I understood it. Changes in wording and question structure were made based on the comments provided by this team. Following this evaluation of the survey, I repeated this process with research participants who filled out the survey as the result of a social media share. The participants who agreed to be contacted for follow-up questioning regarding the scale were asked to similarly critique and interpret certain questions on the scale. One difference between the professional evaluation of the scale and the participant evaluation of the scale was that even though the scale expressly asks about issues of race, often research participants answered these questions in regards to factors such as poverty or socioeconomic status (Brown, 2017). After consulting with my team of colleagues, I decided to

clarify these survey responses this during the follow-up interviews conducted with research participants. Specifically, I crafted semi-structured interview questions, as well as follow-up questions, that unambiguously asked participants to speak to the issue of race. The idea that individuals are hesitant to speak of issues of race, and often instead speak to sometimes-related but not congruent issues of socioeconomic status in specific relation to CRE is not an undocumented phenomenon (Malcom, 2013), and I determined that the best way to address this with my research was to ask participants directly during the interviews to discuss these issues related to race.

In this pilot study, survey participants who accessed and completed the survey via social media were also asked specific follow-up questions via interview designed to evaluate predictive validity. For example, survey question #13 asks: *Do you remember issues of race being taught or discussed in a STEM class?* For respondents who answered on the affirmative end of the spectrum, I asked the follow-up question: *You indicated on the survey that you remember issues of race being taught or discussed in a STEM class. Can you give me an example?* As predicted, all participants who had answered question #13 in the affirmative could give an example when prompted. Multiple other survey responses were followed with questions aimed at triangulating responses and gathering evidence of predictive validity. All responses from participants showed predictive validity.

As a weakness of this study is that the study relies on the participant thoughtfully and accurately answering both survey and interview questions, I believe that this evidence of predictive validity is also a justification for the purposive sampling of social media respondents. Through my pilot study, I found that teachers that I have some preexisting relationship with seem dedicated to providing accurate responses as well as presenting a willingness to participate. For

this dissertation study I used the same social media share technique as the pilot study to gather the foundational survey data. The survey data collected serves two main goals in the context of this research; to provide the data necessary to make purposive sampling decisions and to provide the data necessary to serve as the foundation of the follow-up interviews.

Public Data. As an additional source of data, public data as relevant and available to each participant selected to participate in a follow-up interview was collected and presented in the case stories to provide additional contextual information into the learning pathways of the research participants. Demographic information regarding the participants current teaching context, both at the school level and the district level, are reported to fully illustrate each individual's potential influences in relation to culturally relevant STEM education.

Semi-Structured Interviews. Participants selected on the basis of the purposive sampling needed to build this comparative case (and who indicated willingness to participate further) were contacted following their survey participation to schedule a follow-up interview. These interviews proceed in both a face-to-face fashion and also by using technology to facilitate when geography and timing prohibited personal interviews. All surveys were scheduled within eight weeks of each participant's completion of the survey instrument. The targeted time of the interviews was one hour, although some interviews took more time and some took slightly less time.

These interviews followed a semi-structured format, and interview questions were based on responses to the survey questions. This means that questions unique to each participant and their responses to the survey questions were asked. Additional questions regarding motivations towards teaching and questions requesting more information regarding the participant's educational experiences and expertise were also asked. Sample questions for the semi-structured

interviews, organized by the tenet of CRE they were designed to elicit responses in relation to, are found in Appendix C.

Data Analysis

Case study research can proceed with qualitative, quantitative, or mixed research methods (Rossman & Rallis, 2012). Although I used multiple instruments to gather the data needed to create detailed yet pertinent descriptions of my cases, I proceeded with qualitative thematic data analysis. Surveys combined with public data were used to build and justify diverse, comparative cases, to craft semi-structured interview questions, and to produce a collection of descriptive factors regarding each case (Flick, 2014). These individual case descriptions were used as a point of data triangulation with thematic analysis of each case as a check for trustworthiness of the thematic coding scheme (Flick, 2014; Merriam, 1998). Survey results were not analyzed in-depth for findings, however, as statistically significant sample sizes were not sought or achieved. Findings, instead, will be determined from the comparative, cross-case analysis of a combination of all data collection methods.

Following the creation of a description of each case based on survey responses and publically-available data, interviews were conducted, transcribed, and individually analyzed. Each interview was individually analyzed five times:

- 1) The first analysis was deductively coded each individual participants' interview data for the four tenets of CRE.
- 2) The second analysis focused of the codes identified in relation to the four tenets of CRE, and categorized these codes as *undeveloped*, *developing*, or *proficient*. The rubric used to determine the *undeveloped*, *developing*, or *proficient* sophistication level in relation to CRE is found in Table 4.

- 3) The third analysis looked across all interview data for consistent, emergent themes in relation to the teacher's conception of CRE. Seven themes were identified: the role of relationships, the role of school, the role of community, the role of family, the role of technology, the role of secondary education, and the role of teacher education.
- 4) The fourth analysis deductively coded each individual interview participants' data for the themes that emerged in relation to the teacher's conceptions of or ability to actualize CRE in the STEM classroom.
- 5) The final interview transcript analysis categorized the emergent themes in relation to CRE into two classifications: *catalysts* or *inhibitors* along the teachers' learning progressions in relation to CRE.

Analysis for the Tenets of CRE. Deductive codes identified for the tenets of CRE were further analyzed for their positions along a learning progression in relation to CRE. These codes were categorized as *undeveloped*, *developing*, or *proficient*. In general, *Undeveloped* codes represented statements or beliefs that did not indicate an active learning progression towards CRE. Comments categorized as *undeveloped* showed misunderstandings or non-recognitions of the importance of CRE in the STEM classroom, and/or an unwillingness to implement CRE in the STEM classroom. *Developing* codes represented comments that showed recognition or understanding of CRE, but these understandings were either not fully formed or not actualized in the STEM classroom. These developing codes, however, indicated that a learning progression towards CRE was could be active and possible. *Proficient* codes showed both a sophisticated knowledge and acceptance of the tenets of CRE as well as evidence of the implementation of CRE in the STEM classroom. Explanations of the *undeveloped*, *developing*, and *proficient* codes for each of the tenets of CRE are found in Table 4.

Table 4: Rubric for Undeveloped, Developing, and Proficient Categories of CRE Codes

	Undeveloped	Developing	Proficient
Academic Skills and Concepts	Teacher views students as the sole or majority stakeholder responsible for academic success, OR Teacher sees grades and standardized test scores as a majority measure of Academic Skills and Concepts, OR Teacher approaches academics a completion of events rather than an acquisition of knowledge.	Teacher takes some responsibility for student academic success, OR Teacher struggles to balance the responsibility associated with deadlines and the flexibility needed for academic learning in diverse settings.	Teacher recognizes the importance of academic success for all students' learning. Teacher assumes responsibility for student acquisition of appropriate Academic Skills and Concepts and varies instruction, assessment, and deadlines accordingly.
Cultural Competence	Teacher communicates that culture is not relevant or appropriate in the STEM Classroom, OR Teacher communicates the idea that culture has no bearing or potential bearing on STEM education.	Teacher recognizes the role of culture in the history of STEM, but not necessarily that culture has an ongoing role in STEM, OR Recognition of culture as important in STEM education but indicated struggles to incorporate culture in STEM education.	Recognition of culture as important in STEM education and able to communicate how knowledge of culture and students is able to be incorporated into classroom STEM instruction.
Critical Reflection	Teacher's reflections do not uncover or reveal deep, critical thinking on issues important to STEM education.	Teacher participates in Critical Reflections, but not in the context of STEM education or in collaboration with students.	Teacher presents evidence or reference of Critical Reflections in the specific context of STEM education and with student participation.
Critique of Discourse of Power	Teacher does not acknowledge or recognize positionality and societal power structures.	Teacher recognizes and discusses societal power structures, but not in the context of STEM education or in collaboration with students.	Teacher gives evidence or reference to conducting critiques of discourse of power in the classroom.

Analysis for the Multiple Influences in Relation to CRE. In addition to the deductive coding for the four tenets of CRE, all interview transcripts were coded again for multiple influences that emerged in relation to the teacher's use and/or understanding of CRE. These categories might have appeared in multiple contexts during the interview, but were only recorded as data codes if they were mentioned or discussed in relation to the theory or practice of CRE. The emergent codes identified by this analysis, along with a brief description of the nature of each code, are:

- 1) The role of relationships – this code refers specifically to the role of the teacher-student relationship in relation to enacting CRE in the STEM classroom
- 2) The role of school – this code refers to the role of the entire school in encouraging and/or discouraging CRE. This includes school administration, school faculty, school policies, and school logistics that the interview participant discussed in relation to CRE.
- 3) The role of community – this code refers to the role of the community as a whole in relation to CRE. This includes the immediate community where the school is located, as well as larger and less tangible community aspects like perceptions of the school by the surrounding community, and the values that the interview participants perceive the surrounding community to have.
- 4) The role of family – this code refers to the role of the families served by the school, and how teachers perceive these families in relation to the shared roles and responsibilities between teacher and parent in ensuring tenets of CRE like academic success and Cultural Competence.
- 5) The role of technology – this code was utilized when interview participants referenced various aspects of technology, either educational technology, personal technology, or incidental/societal technology in relation to CRE.

- 6) The role of 6-12 education – this code was used when the interview participant mentioned their own 6-12 education or school experience in relation to CRE
- 7) The role of Teacher Education – this code represents the interview participant specifically mentioning or discussing the role of their teacher preparation coursework or experiences with regard to theory or practice of CRE.

After coding for the above themes in relation to CRE, each theme was additionally categorized as a *catalyst* or *inhibitor* of CRE. *Catalyst* categories referred to themes that were mentioned as a benefit, help, or support of the teacher's ability to enact CRE in the STEM classroom. The *inhibitor* category refers to codes that were identified by the teacher obstacles or impediments to their ability to be a CRE practitioner.

Following the individual analysis of each set of interview data, I engaged in a comparative analysis across cases. Cross-case analysis (Flick, 2014) adds trustworthiness to the strongest themes and categories while exploring differences inherent in social research centered on diverse perspectives. The cross-case analysis for this research includes data from all three stages of data collection; survey data, publically available data, and interview data.

Data and findings are reported in multiple forms in Chapter 4, including presentation of survey and publically available data, the individual case descriptions, the identification of individual case coding and categorization schemes for the interview data, the description of a cross-case analysis, and explanations of summative findings. Both graphic and textual representations for data findings are presented in the following chapter.

Trustworthiness Measures

Trustworthiness and validity are addressed in this research in the following ways:

- 1) Purposive sampling: As this research relies on the honesty and transparency of information provided by research participants, I used a purposeful sample (Patton, 2002) of STEM teachers reached through my professional social media networking.
- 2) Triangulation: Two of Merriam's (1998) described triangulation techniques were used to ensure trustworthiness of data analysis; use of multiple data sources and use of multiple methods to confirm thematic findings. The multiple data sources proposed for use are survey data (and the case descriptions generated from survey data), interview data, and public data. The multiple methods used to confirm the thematic findings include individual case coding and comparative cross-case analysis (Flick, 2014).
- 3) Audit Trail (Merriam, 1998): complete transparency of the research process was maintained in both electronic and paper qualitative research journals, which accounts for and explains the data collection and analytic decisions made throughout the research process, for each case as well as across cases.
- 4) Member-checking: all interview participants were sent their interview transcripts and given the opportunity for feedback. Participants were also asked for any additional comments related to the research topic at that time.

Research Timeline

Following IRB approval, the first stage of data collection (social-media shared survey) took place from April –June 2018. Interviews occurred in June and July 2018. Gathering of publically available data for each interview participant occurred following the survey

participation and prior to the follow-up interview. Participants were contacted for member checking in August 2018, and data analysis continued through September, 2018.

Chapter 4: Analysis and Findings

Introduction: Research Overview

Data gathered from survey participation, targeted interviews, and publicly-available sources were used to investigate the learning pathways of current secondary science, technology, engineering, and mathematics teachers in relation to culturally relevant STEM education. First, survey data was collected via personal social media account share. Next, to provide additional context for the survey responses, publically available data regarding the districts and schools represented by survey participants was also researched. The results from the survey combined with the publically-available data review were used to select interview candidates from unique and varied teaching and learning backgrounds and settings. In presenting the findings of this study, I first describe the participation in this study, and present the teaching and pertinent societal context of each participant.

Research Participants

56 Science, Math, Technology, and Engineering teachers participated in the survey over a time period of 10 weeks. Following their survey completion and an analysis of the survey data, six teachers were selected as focus cases and participated in a follow-up interview. These teachers were selected as focus cases based on survey responses and a review of publically available data, in order to more thoroughly investigate the learning pathways in relation to culturally relevant STEM education. A description of both survey participants and interview participants follows.

Survey Participants

Out of these 56 initial survey participants, 24 individuals met the bounding criteria of being a current (not former or retired) teacher of a STEM field in secondary (6-12) grades.

Additionally, participants who declined to answer three or more of the Likert scale questions on the survey were eliminated from consideration due to some evidence of survey fatigue (the failure of all participants who started the survey to finish the survey). Out of these 24 survey participants, 23 identified as White/Caucasian and one preferred not to answer the question regarding race and/or ethnicity. The 24 survey participants consisted of 11 math teachers, 10 science teachers, two engineering teachers, and one technology teacher. Four survey participants taught in a private school setting while 20 taught in the public school setting at the time of their participation in the survey. Seventeen participants self-identified as female and seven participants self-identified as male. These teachers revealed a multitude of years of teaching experience, ranging from one to 30 years. 10 teachers reported that they had four to six years of teaching experience, and nine teachers identified that they had more than nine years of teaching experience.

The purpose of the survey in the context on this research project was to select a group of focus cases who reported diverse experiences in relation to their conception of CRE. An analysis of the full survey participation identified a focus group of six teachers for participation in follow-up interviews.

Interview Participants

Six survey participants were selected for follow-up interviews. The interview participants were selected on both their willingness to participate as well as their ability to contribute diverse perspectives to the conversation surrounding the multiple influences in relation to enacting culturally relevant secondary STEM education. This group of participants is evenly split among math and science teachers, as well as evenly split by Middle (6-8) and High School (9-12) teachers. These six participants are all current teachers of record at five schools (two Middle

Table 5: Interview Participant Overview

District	Teacher	Grade Level	Subjects currently taught	School	Initial Certification	Additional Endorsement:
Green Valley County	Mrs. Dogwood	7	7th Grade Math, Honors Pre-Algebra	Forestland Middle School	Mathematics 7-12	
	Mr. Redbud	7	7th Grade Math		Elementary 1-8	Mathematics 7-12, Beginning Administrator, National Board Certification
	Mr. Wildflower	9, 10	Biology, Environmental Science	Prairie-View High School	Biology 7-12	
	Mrs. Clover	6,7	6th and 7th Grade Science	Field-meadows Middle School	Elementary 1-8	
Blue Sky City	Mrs. Nimbus	10, 11, 12	Biology, Chemistry, Anatomy and Physiology	Cloudland High School	Chemistry 7-12	Biology 7-12
Rocky River County	Mrs. Trout	9, 10	Algebra 1, Recovery Credit Math	Waterfall Middle and High School	SPED Modified K-12	Middle Grades 4-8, Algebra 1.

schools and three High Schools) in three school districts. Specifics of each participant's teaching context can be found in Table 5. Detailed descriptions of each interview participant, their current school and district contexts for teaching, and their individual data analysis and findings are presented following an examination of the survey data.

Data and Analysis

The data collection for this research included multiple sources and participant groups. As the survey data collection was used in this research primarily to ensure comparative focus cases with diverse conceptions and experiences in relation to CRE, the survey results presented here are limited to the six focus case interview participants. For full transparency, survey data (Figures 1-9) from the full participation in the survey instrument is presented and discussed in Appendix E.

Following the survey data, each interview participant's full spectrum of data (survey data, publically available data, and interview data) are presented and discussed. After the detailed analysis of each interview participants' data, I present a cross-case analysis of all interview participants including data from all sources and the resultant findings of this research.

Interview Participants' Survey Results

As six survey participants were selected for focus case follow-up interview participation, the survey responses represented in Figures 10 through 18 represent the survey responses of only the six interview participants. Individual survey results for each interview participants are presented in their case stories, and a full accounting of the survey responses for each interview participant is found in Appendix E-J. The aggregated survey responses of interview participants are presented here to demonstrate the diversity of experiences, perceptions, and viewpoints represented in the interview portion of this study.

Secondary School Experience. The first section of the survey asked respondents to answer questions regarding their own secondary school and educational experience. Respondents were directed by the survey to think of the school that they attended during the grade that they currently teach. The first two questions asked about school diversity, as represented in Figure 1.

Interview Participants

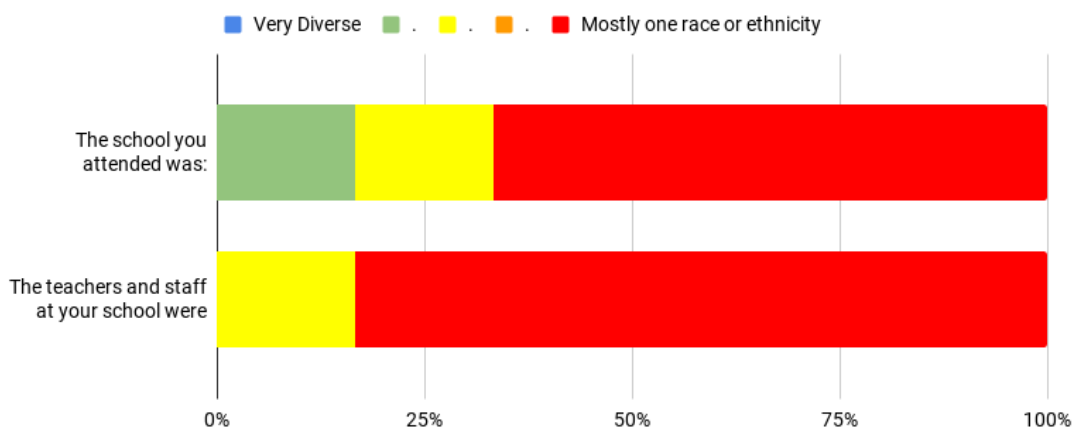


Figure 1: Diversity of Secondary School Experience

Figure 1 shows that four interview participants did not perceive their own secondary school to be diverse, one participant indicated that their secondary setting was *diverse* and one indicated that their secondary setting was *somewhat diverse*.

Still referencing their personal secondary school experience, participants were next asked a series of questions regarding the cultural climate of their experience, adapted from the School Climate for Diversity Scale (Byrd, 2016; Byrd, 2017; Byrd, 2018). Figure 2 shows a breadth of conceptions regarding the participant's experiences as a student at the secondary level: the six interview participants demonstrate at least a three-level range of agreement on all questions on the school scale for diversity, with all but one question representing at least four different conceptions of agreement with the prompt.

Interview Participants

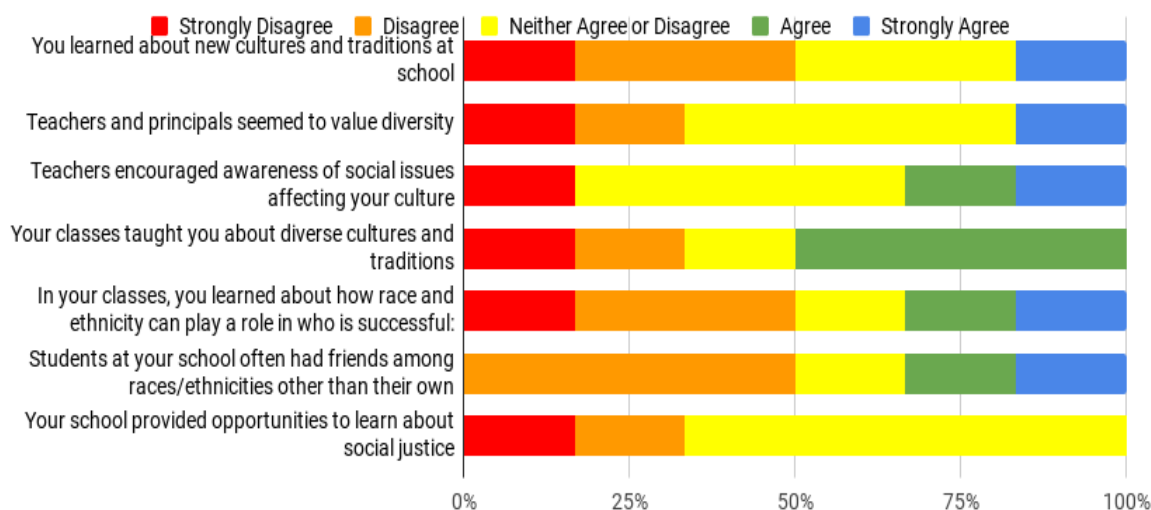


Figure 2: School Climate for Diversity Scale

Interview Participants

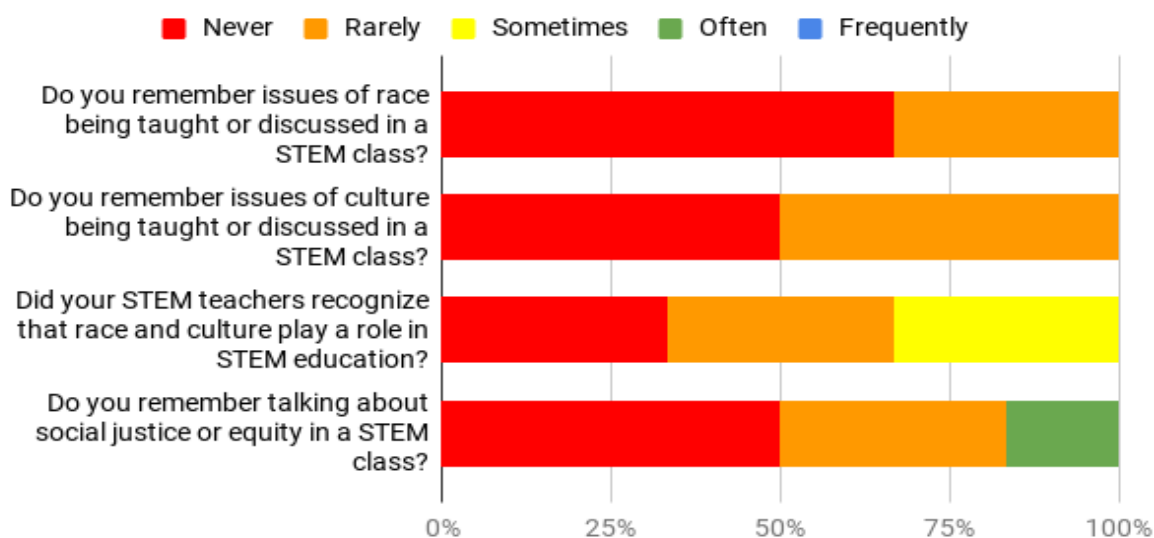


Figure 3: Secondary STEM Experiences

Figure 3 shows much less diversity among interview participants with regard to their conceptions of the secondary STEM classes they participated in as a student. All interview participants report that issues of race or culture were taught or discussed in the STEM classes they took at the *never or rarely* level. Only one interview participant answered that they remembered talking about social justice or equity often in a STEM class; the remaining five interview participants all responded *never or rarely* to that same survey question.

However, a diversity of responses in this category across these questions was hard to come by. When comparing these results to the complete group of survey Participants, Appendix D) it is apparent that most survey participants had similar conceptions of their own secondary STEM learning experiences.

Interview Participants

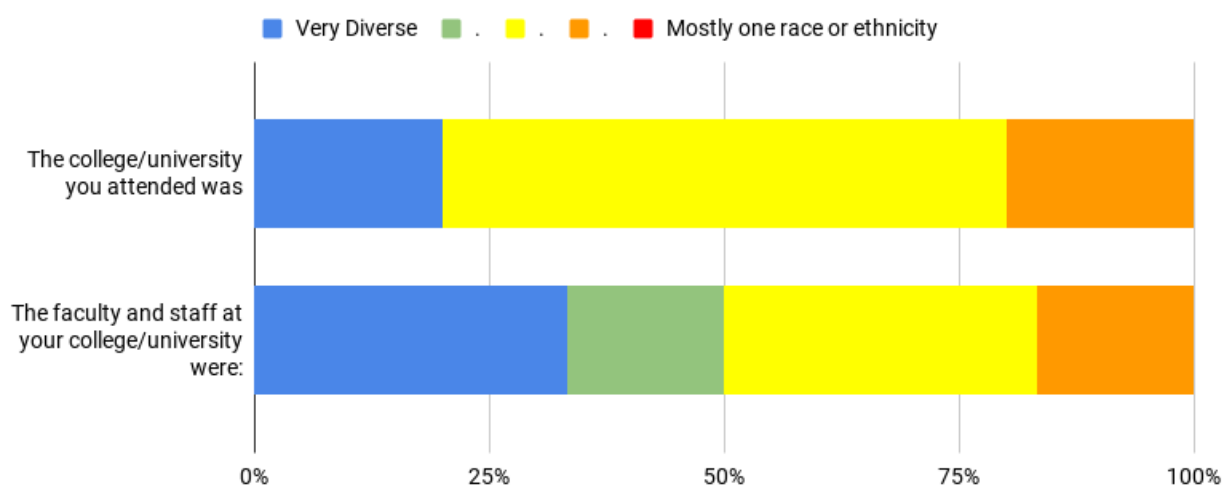


Figure 4: Diversity of Teacher Education Experience

Teacher Education Experience. The next section of the survey asked participants to recall their teacher education experience. They were asked to recall their experience at the

college or university they attended to prepare to become a teacher. The same series of questions were presented again; this time with the participant prompted to answer in regards to their teacher preparation program. Results for this section of the survey are found in Figure 4, Figure 5, and Figure 6.

Interview Participants

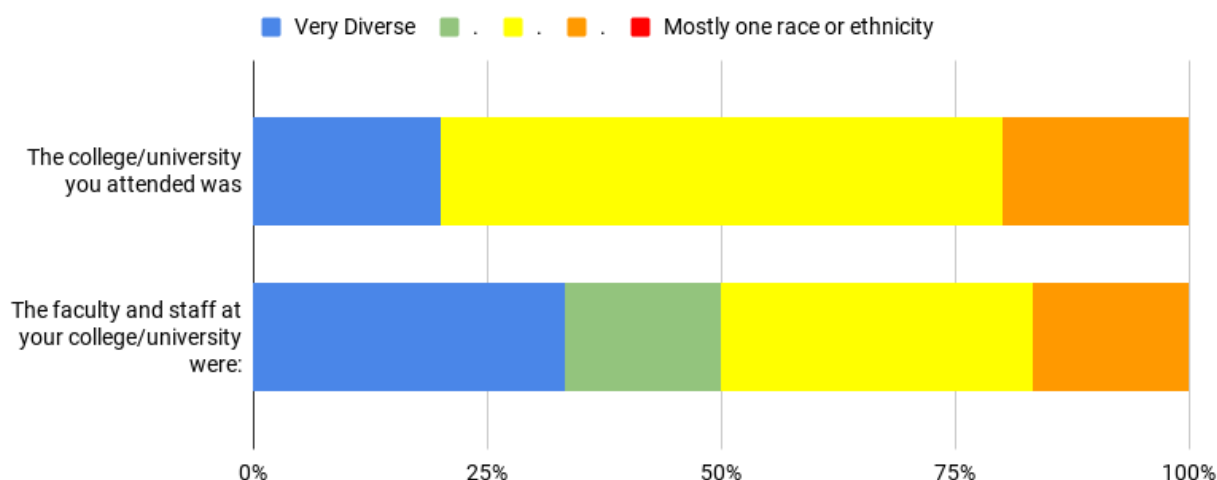


Figure 4: Diversity of Teacher Education Experience

Figure 4 shows a variety of perceptions of the diversity of their teacher education experience by interview participants. While no interview participant identified that their college/university experience was not very diverse, the remaining range of diversity perceptions is represented by the group of interview participants. Figure 5 again shows a range of diversity and multiculturalism perceptions of the college/university experience. It is interesting to note that, while no interview participants identified their colleges/universities students or faculty as *not very diverse*, we see in Figure 5 some responses that indicate that diversity was not always addressed or attended to at the college/university level. For example, one interview participant

indicated that they *strongly disagreed* with the statement that faculty and staff seem to value diversity, and one interview participant *strongly disagreed* with the idea that students at their college/university often had friends among other races/ethnicities than their own.

Interview Participants

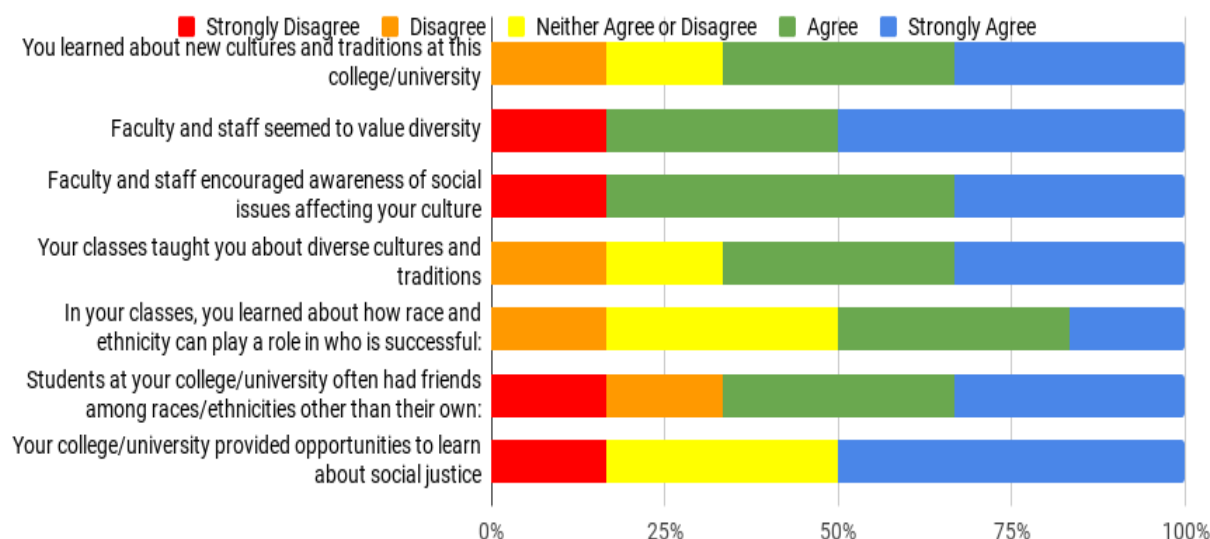


Figure 5: School Climate for Diversity Scale Responses

Similar to the results seen with the entire population of survey respondents, Figure 6 shows that interview participants overall have more recollections of issues of race and culture being taught or discussed in their post-secondary STEM courses when compared to their recollections of their secondary STEM courses. However, a range of perceptions is still present among interview participants: the range of *never* to *frequently* is seen on one question, with the range *rarely* to *frequently* present in the remaining questions regarding perceptions of STEM courses at the post-secondary level.

Interview Participants

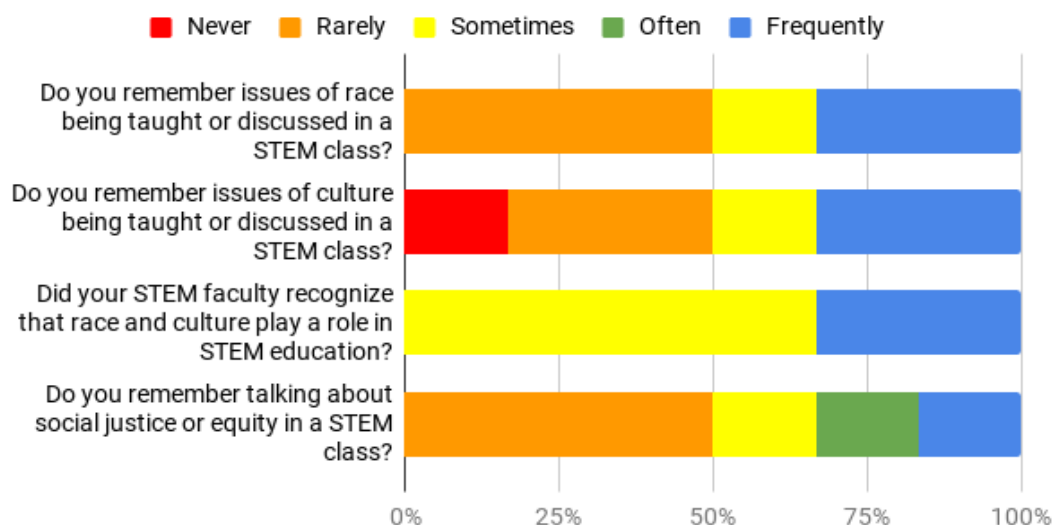


Figure 6: STEM Experience at the Teacher Education Level

Secondary STEM Teaching Experience. The third and final series of questions in this survey asked participants to consider the school environment in which they currently teach a STEM content-area course.

As the focus of this research is teachers of diverse students, it was necessary to select interview participants who perceive a level of diversity among their current students. With respect to this research focus, survey participants who did not report being teachers of diverse students were not selected for a follow-up interview. Figure 8 demonstrates that all interview participants identified their current school in the range of *somewhat diverse* to *very diverse*. Figure 9 also shows that the majority of interview participants responded in the neutral or affirmative range on the School Scale for Diversity (Byrd, 2016, 2017, 2018) questions. Individual, specific perceptions of diversity were explored further in the follow-up interviews.

Interview Participants

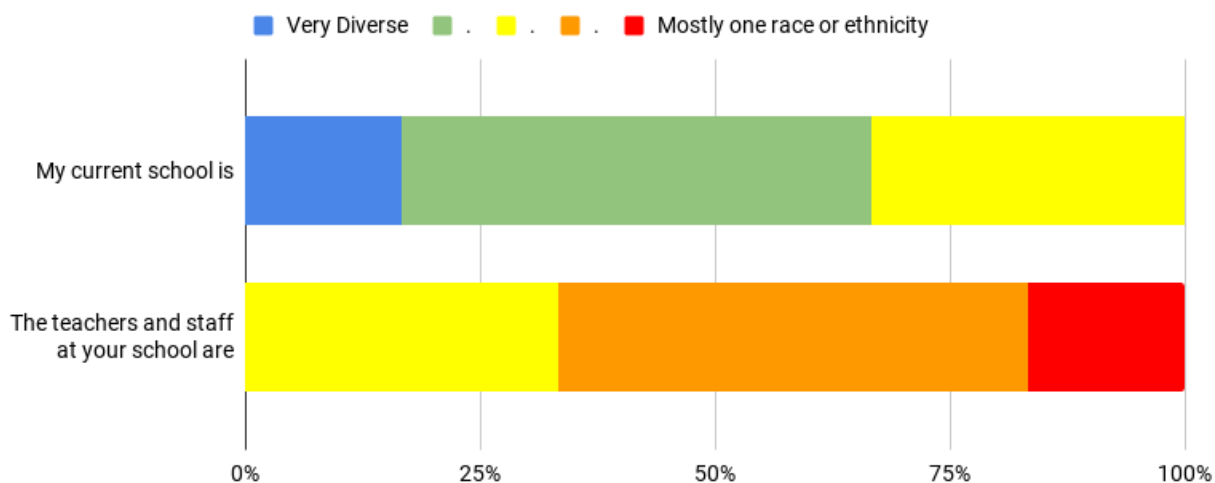


Figure 7: Diversity of Current Teaching Environment

Interview Participants

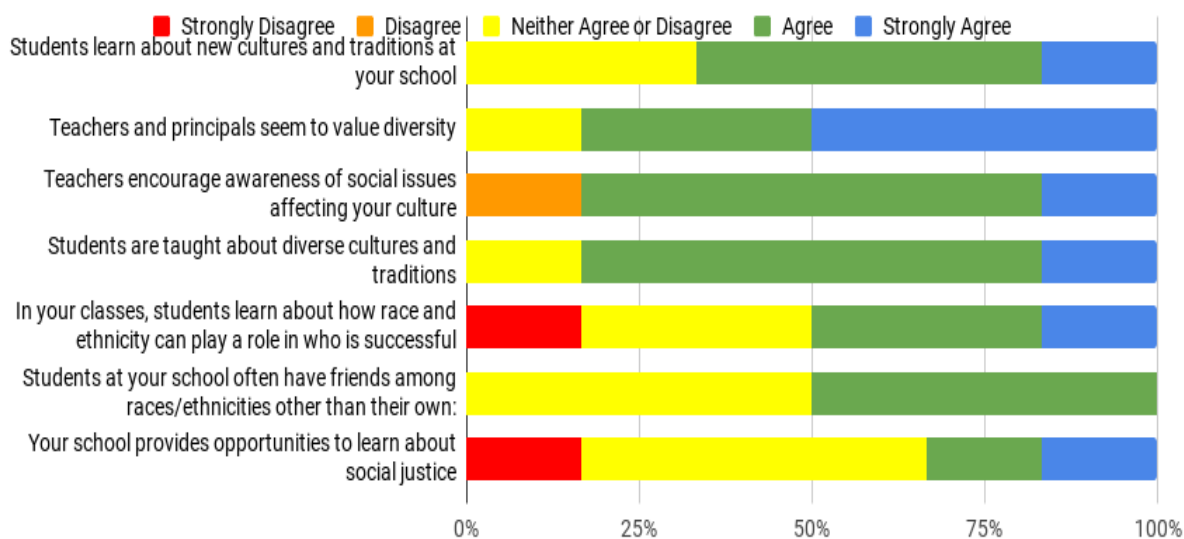


Figure 8: School Climate for Diversity Scale Responses

Interview Participants

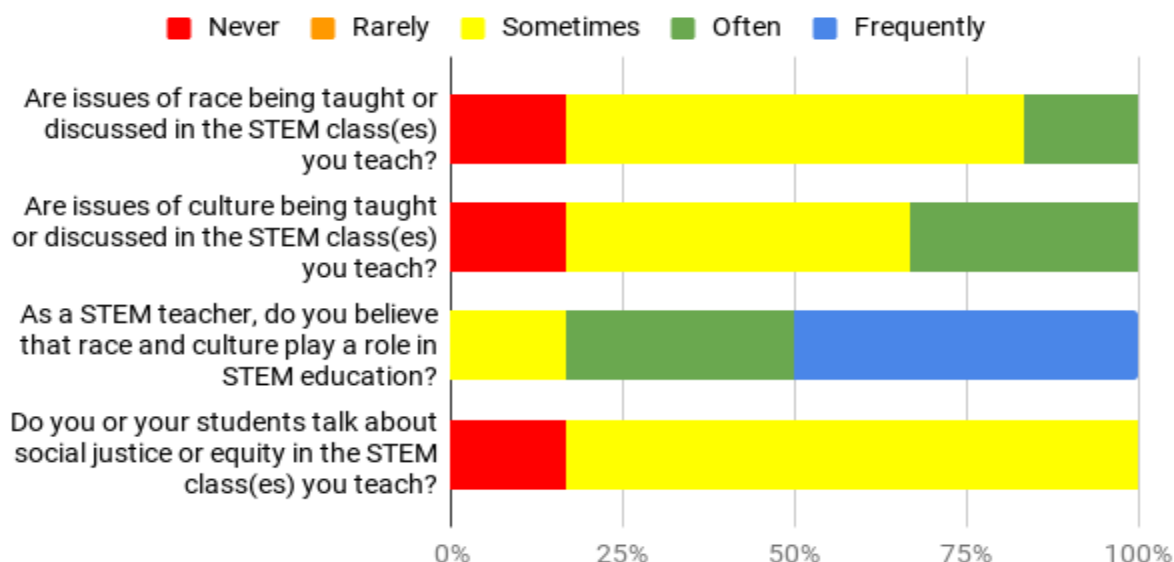


Figure 9: STEM Teaching Experience

Figure 9 shows the interview participants responses to the questions that specifically asked about race, culture, social justice, and equity in the STEM classes they currently teach. As this research is looking to explore all learning pathways in relation to CRE, including those learning pathways that might not be on a trajectory towards CRE proficiency, a diversity of responses was needed here as well in order to create comparative cases. Additionally, given the research purpose, participants were not required to be self-reported exemplars in implementing and actualizing CRE in their STEM classes in order to be selected for a follow-up interview. Figure 9 shows that interview participants do have a range of conceptions about the role of race, culture, and social justice in the STEM classroom. No interview participants reported race, culture, or social justice were frequently taught or discussed in the STEM classes they teach. When asked if race and culture were taught and discussed in their STEM classes, this group responded in the range of *never* to *often*. When prompted about the frequency of social justice and equity issues in the STEM classroom, this group responded *never* or *sometimes*. Of note is

that the majority of this group (five out of six participants) responded in the affirmative that as a STEM teacher, they believe that race and culture play a role in STEM education. With respect to individual survey responses, this appearance of a disconnect between personal beliefs and personal teaching practice in the STEM classroom was addressed during the follow-up interviews.

The above survey responses of interview participants demonstrate the construction of a diverse and varied set of perceptions and experiences, while still meeting the bounding criteria of the research study and maintaining specific characteristics of participants needed to investigate the research question.

Findings of Focus Cases

As presented above, six teachers were selected as focus cases to participate in follow-up interviews. In addition to the diversity of experiences and conceptions about STEM teaching identified by the survey, additional items taken into consideration while selecting a diverse case of interview participants included subject taught (three math and three science teachers were selected for interview participation), grade level taught (three middle school and three high school teachers were selected).

Additionally, the teaching context for these interview participants is varied: the interview participants teach in five different schools located in three different school districts. All three districts are located in the same state within the southeast region of the United States. While the districts are not contiguous, they are all located within an 80-mile radius of each other, and all are located within 40 miles of one of the largest metropolitan areas in the state.

These districts provide a unique context to explore culturally relevant education and issues of social justice. Within the past year, two of the three represented districts received news

coverage regarding two issues pertinent to this research. One issue is the demographics of the teaching force as compared to the demographics of students within these districts, and the other is the demographics of students disciplined within the districts as compared to the demographics of the districts as a whole. As the teaching force and discipline demographics data are closely related to the research topic, they are presented for each school district represented in this research.

Interviews were conducted and analyzed as described in Chapter 3, and the findings of the interview participation are presented now. Following the findings for each individual interview participant, I present a cross-case analysis of all focus cases. The focus cases are discussed in the following order:

- 1) Mrs. Dogwood, Math, Forestland Middle School, Green Valley County Schools.
- 2) Mr. Redbud, Math, Forestland Middle School, Green Valley County Schools.
- 3) Mrs. Clover, Science, Meadows Middle School, Green Valley County Schools.
- 4) Mr. Wildflower, Science, Prairie View High School, Green Valley County Schools.
- 5) Mrs. Nimbus, Science, Cloudland High School, Blue Sky City Schools.
- 6) Mrs. Trout, Math, Waterfall Online School, Blue Sky City Schools.

Mrs. Dogwood

Mrs. Dogwood teaches seventh grade mathematics at Forestland Middle School located in Green Valley County school district. Mrs. Dogwood has been teaching mathematics for about five years, and the entirety of her teaching career has been at Forestland Middle in Green Valley County. Green Valley County is considered a large district for this region, encompassing over 80 schools, employing near 6,500 faculty and staff, and serving between 60,000 and 65,000 students. This district spans urban, suburban, and rural areas of the same county. Graduation

rates have risen in the past five years from near 85% to almost 90%. The average yearly per-student expenditures in this district are between \$9,000 and \$9,500.

Green Valley County's teaching force is not representative of the population of the district as a whole with respect to representations of race and gender, as shown by Table 6. Additionally, Green Valley County shows disproportionate instances of discipline resulting in missed classroom instruction time for non-White students, as shown in Table 7. The data in Table 6 and Table 7 were compiled from publically-available data provided by Green Valley County, the state Board of Education, and the state Department of Education. These data are presented here to show the context in which Mrs. Dogwood teaches.

Table 6: Green Valley County: Community, Student, and Teacher Demographics

Green Valley County: Demographic comparisons			
Subgroup	% of total surrounding community population	% of total students population	% of total teaching population
White:	85%	60%	90%
Black:	10%	35%	3.5%
Hispanic/ Latino:	5%	5%	1.5%
Asian:	2%	<1%	<1%
Male:	48%	49%	22%*
Female:	52%	51%	78%*

Table 7: Green Valley County Discipline by Subgroups

Green Valley County: Student Demographics and Discipline Rates			
Subgroup	% of total student population	% of students (by subgroup) referred to ISS	% of students (by subgroup) referred to OSS
White:	70%	60%	60%
Black:	17%	35%	35%
Hispanic/ Latino:	10%	5%	5%
Asian:	3%	<1%	<1%
Economically Disadvantaged:	45%	70%	80%
English Language Learners:	2%	5%	5%
Identified Disabilities:	15%	20%	23%
Male:	50%	65%	68%
Female:	50%	35%	32%

Forestland Middle School is located in an urban/suburban community in Green Valley County. Forestland draws from diverse communities, both racially and socioeconomically. The student demographics for Forestland are: White (70%), Black (10%), and Hispanic/Latino (>8%). About 5% of students at Forestland receive English language learner support, and almost 15% of students have an individualized education plan. While the zoning for Forestland includes some notably affluent areas, this is a Title 1 school, and close to 35% of students receive free or reduced lunch.

Forestland is a 1:1 technology school, where most of the students in the school have access to a personal technological learning device, such as a tablet or a laptop, provided by the school. While not officially designated (or funded) as a 1:1 school by Green Valley County, a collaborative effort of fundraising through the school's support organizations have financially

supported this initiative. Forestland operates on a standards-based assessment system, where students are assigned proficiency levels (rather than letter grades) based on identified subject-area standards. Forestland Middle also operates on a “team” system, where students with similar needs are grouped together with a set of teachers specific to that group of students. Mrs. Dogwood’s team is responsible for the instruction of students identified into an accelerated math curriculum.

Mrs. Dogwood’s Survey Participation. A full report of Mrs. Dogwood’s survey responses is found in Appendix D. Based on her survey responses, Mrs. Dogwood was selected to participate in a follow-up interview for multiple reasons. Mrs. Dogwood indicated that the secondary school she attended was *mostly one race or ethnicity*, which is in contrast to what she reported for her teacher education experience (*very diverse*) as well as her current teaching context (*diverse*). Mrs. Dogwood reports that although her university as a whole was *diverse*, she selected *strongly disagree* in response to the prompt that asked if faculty and staff seemed to value this diversity. She also *disagreed* that her classes taught her about diverse cultures and traditions, and she *strongly disagreed* when asked if her college/university provided opportunities to learn about social justice. However, when asked specifically about her STEM content or teaching methods courses, Mrs. Dogwood *frequently* remembered issues of race and culture being taught or discussed, and she remembered talking about social justice or equity in a STEM class *often*. When asked about the STEM classes that she currently teaches, Mrs. Dogwood responded that issues of race and culture are *sometimes* being taught in her STEM classes, her students *sometimes* talk about social justice, and she *sometimes* believes that race and culture play a role in STEM education.

Mrs. Dogwood was selected as an interview participant based on the following factors:

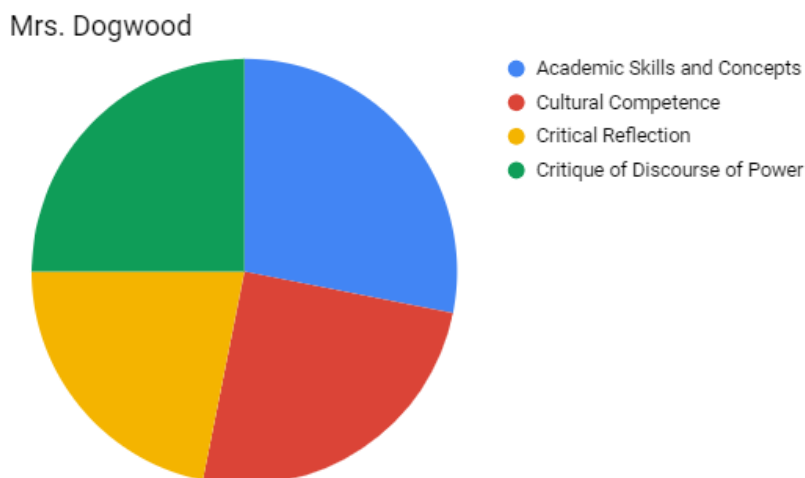


Figure 10: Mrs. Dogwood's Expressed Tenets of CRE

- 1) To explore how her secondary education experience consisting of *mostly one race or ethnicity* and her *very diverse* post-secondary experience have influenced her current teaching,
- 2) To investigate the potential impact of her recollections of *frequent* discussions of race and culture in STEM content or teaching methods classes at her university in relation to her use of CRE, and
- 3) As Mrs. Dogwood indicated that the classes she teaches *sometimes* addresses issues of race, culture, social justice, and equity, she was selected as a participant who may have both proclivities and obstacles to the implementation of CRE in her classroom.

Mrs. Dogwood's CRE Profile. Mrs. Dogwood's interview data was analyzed to create a CRE profile that establishes her proficiencies towards enacting the tenets of CRE in her classroom. First, the interview data was deductively coded for the four tenets of CRE: Academic Skills and Concepts, Cultural Competence, Critical Reflection, and Critique of Discourse of Power. Each code regarding the tenets of CRE was then categorized as *undeveloped*, *developing*, or *proficient* using the indicators presented in Table 4: *Rubric for Undeveloped, Developing, and*

Proficient Categories of CRE. This data analysis was used to create Mrs. Dogwood's CRE profile.

Figure 10 shows the frequency that Mrs. Dogwood discussed each of the four tenets of CRE in her interview. Mrs. Dogwood's discussed each tenet of CRE almost equally in her interview, with 21.7% of her CRE references relating to Critical Reflection, 25% of her CRE references relating to Cultural Competence, 25% relating to Critique of Discourse of Power, and 21.8% relating to Academic Skills and Concepts.

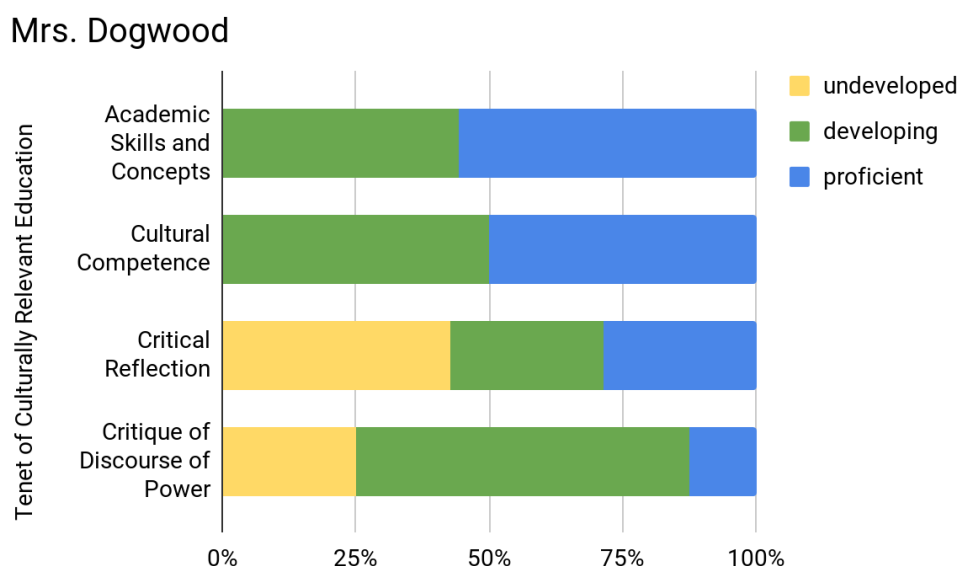


Figure 11: Mrs. Dogwood's Proficiencies in Relation to CRE

Figure 11 shows Mrs. Dogwood's percentages of *undeveloped*, *developing*, and *proficient* categorizations for each of the tenets of CRE. This shows that while Mrs. Dogwood displays *developing* and *proficient* levels of CRE for all tenets, she also shows *undeveloped* categorizations for Critical Reflection and Critique of Discourse of Power.

Academic Skills and Concepts. Mrs. Dogwood most often discussed in the interview how she helps her students obtain Academic Skills and Concepts, and her categories for this tenet of CRE were all *developing* (44.4%) or *proficient* (55.6%).

Given the building nature of math, Mrs. Dogwood discussed gaining proficiency on basic skills as necessary to progress, and that students gaining these proficiencies is necessary not just for current academic success but also for future success in mathematics: “In the last two years I’ve started doing more personalized learning, and I really feel like that helped fill in the gaps with some of those kiddos that are a little more behind. And if you’re going by standards based grading, you can really pick up on the standards that the kid has not mastered early to try and do a good job of getting them that extra support.” (M. Dogwood, interview, June 4, 2018). This comment regarding the academic potential and success of her students was classified as *proficient* because Mrs. Dogwood mentioned her role in ensuring the academic success of her students by varying her instruction according to the student’s needs.

Mrs. Dogwood discussed several aspects of how she organizes her instruction with respect to ensuring students both experience academic success and acquire academic skills necessary for future success. As she explained above, she operates her classroom grading system with a standards-based format, which gives credit to students for demonstrating mastery on skills and concepts rather than completing a series of events or turning in a series of assigned activities. As a part of this system Mrs. Dogwood described her decision to limit homework: “you can tell, like, you can tell the kids that have more support at home versus the kids that don’t, so again, it comes to how do you engage them in class and pull it out of them in class and not rely on the homework aspect. So one of the things we work on is limiting homework unless it is really needed. I feel like this has really helped some of these kiddos that have less support at home (M.

Dogwood, interview, June 4, 2018). This explanation that homework, albeit unintentionally, advantages and furthers the privilege the students who have help and support at home is an example of a *proficient* level in regards to Academic Skills and Concepts as it shows the teacher's ability to vary instruction and assessment with regard to her students' specific learning needs and assets.

Additionally, Mrs. Dogwood mentioned her homework policy when asked about potential achievement gaps in mathematics among different genders and races: She stated that "I used to assign and grade homework" but that she now believes her limited homework policy "helps eliminate some of the gaps" (M. Dogwood, interview, June 4, 2018). This comment was also classified as *proficient* in the realm of Academic Skills and Concepts, as it showed Mrs. Dogwood's personal responsibility for student academic success, to the extent that she has changed her instruction and assessment policy to eliminate learning/achievement gaps and accommodate all students' acquisition of skills and concepts.

Cultural Competence. Similar to Academic Skills and Concepts, all of the representations of Cultural Competence in Mrs. Dogwood's interview were *developing* (50%) or *proficient* (50%). When asked how the diverse background cultures of her students impacts her lesson planning or her teaching style, Mrs. Dogwood responded: "If you know your kids' pasts or their backgrounds, a lot of times I try to find something they are passionate about and draw in [into the class] something they are interested in. And also . . . maybe not bringing up sensitive topics, or knowing if something is going on at home that could trigger a response in class, so it's also using it as a 'don't go there' kind of thing" (M. Dogwood, interview, June 4, 2018). This statement was classified as a *developing* level of Cultural Competence, because Mrs. Dogwood

recognizes that student cultural backgrounds and interests are important, but she does not clearly explain how to integrate this information into STEM education.

Mrs. Dogwood also showed *proficient* levels of Cultural Competence. When asked how she addresses issues of power when teaching a subject area historically dominated by White men, Mrs. Dogwood stated: “Well, the kids need to know that there are women who do this [math], and not just women but of course all different races as well. And I feel like if they see this and they know this, then they will realize that they can do it. So sometimes it’s just showing them as much as possible the people who are doing STEM who look like them, or maybe who don’t look like them. We’ve been able to watch the movie *Hidden Figures*, you know, because it’s math, and I think that’s opened some eyes.” (M. Dogwood, Interview, June 4, 2018). This statement in relation to Cultural Competence was categorized as *proficient* because Mrs. Dogwood gave an example of why culture is important in STEM education and also how it can be used and discussed in her classroom.

Critical Reflection. When talking about Critical Reflection realm of CRE, Mrs. Dogwood showed a larger percentage of *undeveloped* codes (49.2%) than *developing* (28.6%) or *proficient* (28.6). In response to questions about engaging her students in real-world problem solving or conversations about controversial math or science-based issues, she repeatedly responded with the sentiment of “I just can’t go there,” “That’s out of my comfort zone,” and “there are some things that I am just not comfortable with” (M. Dogwood, interview, June 4, 2018). These statements show an *undeveloped* level of Critical Reflection as they show an avoidance of issues of race and culture in STEM education. When asked if she could design and implement lessons that incorporate cultural or societal issues that her students face, she responded; “Yes and no. I mean, I could, but I’m more hesitant because of the stepping on toes. I mean, it might be okay

with one kid but with the next kid it might not be” (M. Dogwood, Interview, June 4, 2018). This statement was categorized as *undeveloped* given Mrs. Dogwood’s hesitancy to consider the role of cultural or societal issues in STEM, showing a lack of reflection on this particular concept.

However, Mrs. Dogwood also showed *developing* and *proficient* levels of Critical Reflections. When asked how race and culture play a role in math education, she responded: “I feel like for the math I teach in 7th grade, maybe they don’t, or maybe I’m not seeing it currently. You know, it’s adding subtracting multiplying dividing rational numbers or fractions, or integers. I feel like [issues of race and culture] are more conversation-based? Where do we have conversations in math?” (M. Dogwood, Interview, June 4, 2018). Some of Mrs. Dogwood’s *developing* comments in relation to Critical Reflections referenced plans to enact this tent of CRE in the future. When asked if her students discuss topics of social justice in her class, Mrs. Dogwood responded “Well, I’m trying to start to put a piece together for that for next year” (M. Dogwood, interview, June 4, 2018). These comments showed a *developing* understanding of the role of Critical Reflection as it shows Mrs. Dogwood actively considering her position about the roles that social justice plays in the STEM classroom, but without being able to identify a specific context (yet) for this reflection to occur in her classroom.

Despite her stated hesitancy to engage in Critical Reflection with her students, Mrs. Dogwood also showed *proficiency* in this realm of CRE. When asked how she fosters students to critical thinkers and communicators, she explained that critical problem solving is one thing they do engage with in her class. She has been using Dan Meyer’s The Three Acts of a Mathematical Story, in which students are introduced to an engaging picture or video that has an unresolved conflict and students try to predict a conflict resolution using mathematical knowledge (Meyer, 2011). Mrs. Dogwood stated that she adapted this method to allow students to pick the picture or

video themselves, and explained that “students create the problem themselves, and I feel like this helps tremendously, because it’s already relevant to them if they create it themselves. And sometimes the [math] problem gets messy because they create it themselves. And that gets them talking about math, it’s weird, they’re actually talking about what they are supposed to be talking about. But I think you have to put them in the situation to be problem solvers and critical thinkers, and not take them out of it when it gets tough. As a teacher you almost have to be out of the comfort zone yourself, and most teachers won’t relinquish that power” (M. Dogwood, Interview, June 4, 2018). This quote shows a *proficient* level of Critical Reflection as Mrs. Dogwood referenced a critical discussion, occurring in her classroom, that is directly related to both mathematics and student lived experiences.

Critique of Discourse of Power. While Mrs. Dogwood showed some *undeveloped* codes in the Critique of Discourse of Power realm of CRE (25%), she also showed a majority (62.5%) of *developing* codes, and also *proficient* codes (12.5%). When asked how she addressed political or controversial issues based on scientific and mathematical models (such as climate change) in her class, she responded “as an educator, especially a public educator, you’ve gotta be careful about what you say and not let your personal agenda get in the way. Because it can get you in trouble in a hurry if you do that” (M. Dogwood, Interview, June 4, 2018). This comment represented an *undeveloped* view of Critique of Discourse of Power, as Mrs. Dogwood, while possibly stating a reality, did not recognize or acknowledge societal power structures in her response.

Mrs. Dogwood showed a majority (62.5%) of comments categorized as *developing* related to Critique of Discourse of Power. For example, when asked if students in her class learn about how race, gender, or ethnicity can play a role in who is successful, she discussed: “I think

that seeing people who are like you, and being successful, plays a significant part in where students go when they get older. Fighting the stereotypes, that you're going to end up like everyone around you, everyone you know. Which is hard, because society keeps beating you down, even as an adult" (M. Dogwood, interview, June 4, 2018). This comment shows a *developing* level of Critique of Discourse of Power, because although societal power structures are identified and discussed in the context of students, Mrs. Dogwood did not relate this to the specific arena of STEM education.

Catalysts and Inhibitors of Mrs. Dogwood's CRE Profile. Following the analysis of interview transcripts for Mrs. Dogwood's proficiencies on the four tenets of CRE, the interview data were further analyzed for the influential themes that emerged in relation to CRE. These themes, identified through an initial coding of all interview transcripts, are the role of relationships, the role of the current school setting, the role of the surrounding community, the role of family, the role of technology, and the role of the teacher preparation experience. Mrs. Dogwood's distributions of these themes are found in Figure 12. While Mrs. Dogwood did not

Mrs. Dogwood

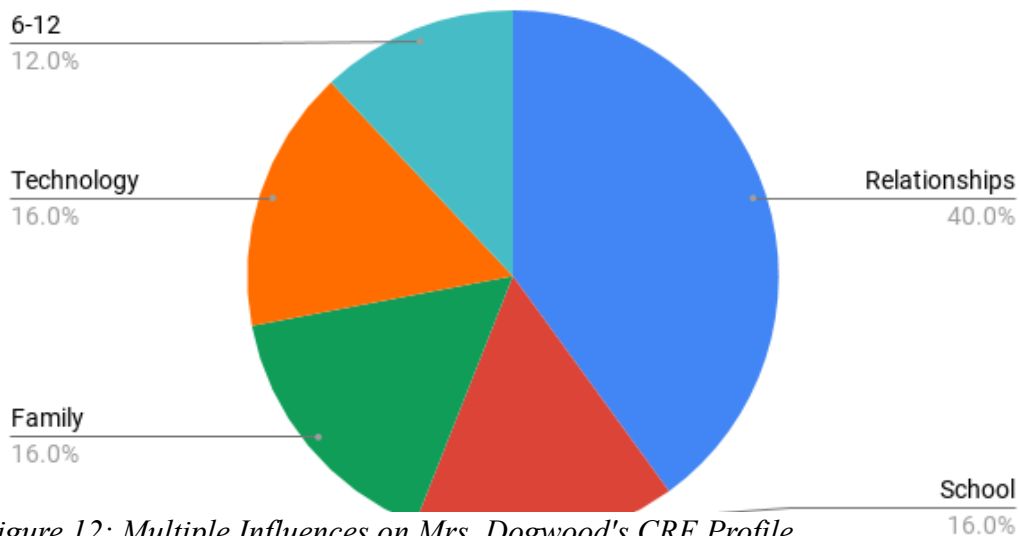


Figure 12: Multiple Influences on Mrs. Dogwood's CRE Profile

discuss the role of family in relation to her ability to enact CRE in the classroom, she did discuss the remaining six themes. The themes that Mrs. Dogwood discussed in relation to CRE were additionally categorized as *inhibitors* or *catalysts*, based on if they encouraged or helped her use of CRE (*catalysts*) or impeded her use of CRE (*inhibitors*). Figure 13 presents the *catalysts* and *inhibitors* in regards to Mrs. Dogwood's CRE profile. Figure 13 presents the *catalysts* and *inhibitors* in regards to Mrs. Dogwood's CRE profile.

Mrs. Dogwood

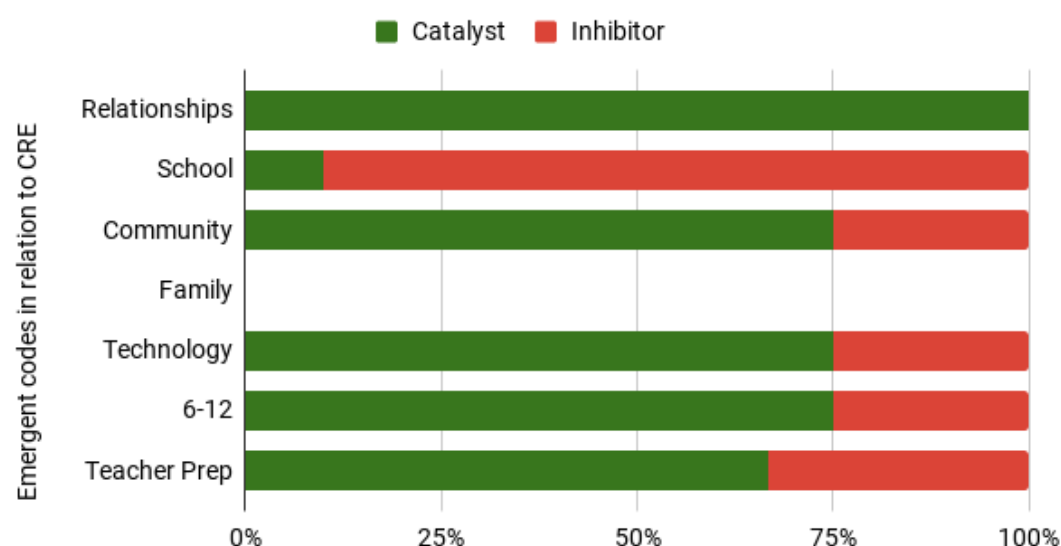


Figure 13: Catalysts and Inhibitors of Mrs. Dogwood's CRE Profile

The role of relationships. In examining the distribution of Mrs. Dogwood's influences of CRE, she talked about the role of relationships with her students more than any other influence in relation in relation to her ability to be a practitioner of CRE. Additionally, all of Mrs. Dogwood's references to the role of relationships were described by her as *catalysts* of CRE. When asked how the theory and philosophy she learned during her teacher preparation impacted

her current teaching style, she responded: “Well, at the end of the year, I want my students to know that I’m there for them to support them with whatever. It’s not just that I taught them math for a year. It’s spending those times to build those relationships with students, and that’s way more than just teaching to the test or mastering a standard, it helps them want to learn and want to continue learning” (M. Dogwood, Interview, June 4, 2018). This comment was categorized as a *catalyst* of CRE because Mrs. Dogwood explained how relationships with her students helped ensure academic success for her students.

When asked about how she meets the needs of all of the students in her classroom, Mrs. Dogwood identified relationships with students as a *catalyst* of CRE in this manner “at the end of the day, I work with twelve and thirteen-year-olds, you know? What you get from them one day is not what you’re going to get from them the entire year. If the kid is having a bad day it could be that they’re becoming a teenager, or it could be something going on at home, or it could be something going on in the world . . . whatever it is, it’s affecting them. And it’s my job to realize that and to know what I can do to help, and to make sure they trust me so I can help. They’re kids. They’re just kids. They’re all different, and you gotta do what you’ve gotta do as a teacher to get them to be their best self” (M. Dogwood, interview, June 4, 2018). In this statement, Mrs. Dogwood recognizes that forces outside of the STEM classroom play a role in STEM education, and that her relationships with her students are key to helping students achieve to their potential.

The role of school. While only 16% of Mrs. Dogwood’s comments identifying influential factors to her implementation of CRE mentioned the role of her current school context, Figure 14 shows that 90% of these codes identified the role of the school as an *inhibitor* of implementing and enacting CRE. In a conversation prompted by the question *does your*

Mrs. Dogwood

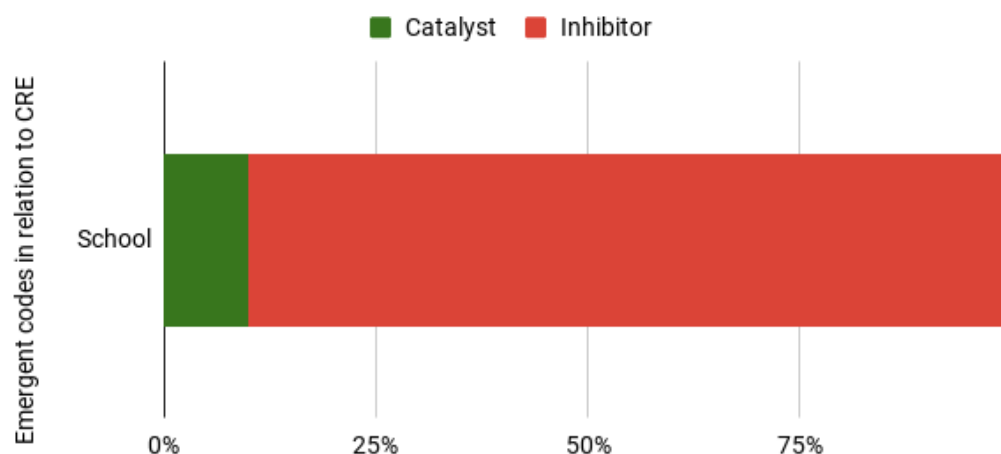


Figure 14: Inhibitors of Mrs. Dogwood's CRE Profile

school value diversity, Mrs. Dogwood mentioned many things her school could do better to demonstrate a value for diversity. One of her suggestions was “we need to work on having extracurriculars and other opportunities for the kiddos that don’t normally involve themselves. If you look at the clubs, they are all middle class White kids, and others aren’t involved. I dunno, maybe they don’t have a ride home, or their parents can’t afford for them to join this club or that club, or maybe it’s just not their interest. Maybe we only have clubs that the middle class White kids are interested in” (M. Dogwood, interview, June 4, 2018). This comment demonstrated an *inhibitor* in relation to CRE, as this identifies a lack of Cultural Competence of the school environment and a school practice, unintentional as it may be, that excludes students from school culture.

When asked about the effectiveness the strategies she uses to meet the needs of all learners, Mrs. Dogwood explained “it’s hard, and not as effective, when not everyone else [other teachers] are doing it. I mean, the kids come to us from 6th grade not knowing how to have a

conversation in math [class]. They're used to doing worksheets in math. And then they go to 8th grade and those teachers aren't going to continue on with it, you know? It's hard" (M. Dogwood, interview, June 4, 2018). This comment indicated as *inhibitor* in relation to Mrs. Dogwood's ability to engage in critical discourse and meet the academic needs of her students, as she laments the lack of consistency and support among school faculty.

The role of community. Mrs. Dogwood mentioned the role of the surrounding community as both a *catalyst* (75%) and an *inhibitor* (25%) of CRE. She mentioned the efforts of a nearby after-school program to communicate with the school to help support students' academic success. She stated that this program "figures out what the school is doing and what the kids are learning, and then they back that up for the little while they [the students] are with them for afterschool or activities" (M. Dogwood, interview, June 4, 2018). This is an example of a *catalyst* of CRE, as Mrs. Dogwood describes a community stakeholder specifically reaching out to the school to ensure they are supporting the Academic Skills and Concepts that are introduced at the school.

However, Mrs. Dogwood also mentioned that there was a lack of other, similar community groups doing the same: "I feel like they, too, need to be knowledgeable about what goes on at the school so they can help. I feel like everybody just kind of, I mean it's hard, don't get me wrong, it's very hard to do. But I feel like everybody just needs to talk to everybody, and that's difficult to do, and time constraints gets in the way, I get that. But that fluidity needs to be there more that it is" (M. Dogwood, Interview, June 4, 2018). This shows an example of how the community is an *inhibitor* of CRE through the description of a missed opportunity to best support the Academic Skills and Concepts of students.

The role of technology. As with the role of community, Mrs. Dogwood spoke of the role of technology as both a *catalyst* (75%) and an *inhibitor* (25%) in relation to CRE. Mrs. Dogwood spoke of technology as a *catalyst* of CRE by repeatedly, in response to multiple prompts, mentioning that technology provides her with the ability to differentiate and meet the needs of diverse learners. For example, in response to a question about what she does in her classroom if a student fails a test, she stated: “well, I can pull a small group for like 10-15 minutes and work with those group of kids who are missing something, and the rest of the class can keep working on their Chromebooks. Or, I maybe I’m teaching, and the kids [who need extra help on a topic] can get a Chromebook and go to the other side of the room and watch a video or tutorial on what they’ve missed” (M. Dogwood, Interview, June 4, 2018).

An additional example of Mrs. Dogwood mentioning technology as a catalyst of CRE came in response to a question asking her to evaluate the effectiveness of the strategies she uses to meet the needs of all students in her classroom: “I think this [differentiation using Chromebooks] is my best path forward. I think so, absolutely. Especially giving kids that voice and choice. . . all kids are different. Some would rather sit and take notes with me, some would rather watch a video, some would rather play math games or apps or play around with a simulation, so you can hit all the different learning styles as well (M. Dogwood, Interview, June 4, 2018). These examples of Mrs. Dogwood discussing her technology use in the classroom were deemed *catalysts* of CRE as she describes them as beneficial to both the academic success of her students as well as her ability to meet the individual needs of diverse students in her STEM classroom.

However, Mrs. Dogwood also mentioned the *inhibiting* potential of technology in relation to CRE in the context of exposing students to stereotypes and negative influences. When

asked if students learn about how race and ethnicity can play a role in who is successful in her math classroom, Mrs. Dogwood responded: “when you start talking to them you realize they make a lot of assumptions, like, they have no idea. I mean, they see what’s on TV and they watch YouTube videos on their phones, and social media, that aren’t things they should be watching. Like they see all the bad and the negative stereotypes, they don’t see the good or the success stories” (M. Dogwood, Interview, June 4, 2018). This shows the potential for technology use to *inhibit* CRE by discouraging student acquisition of Cultural Competence.

The role of secondary education. Mrs. Dogwood’s references to her own secondary school experience showed both catalyst (75%) and inhibitor (25%) categorizations. When talking about how she wanted, at that time, to become an engineer, she stated that “my high school math teachers always encouraged me and pushed me in school” (M. Dogwood, Interview, June 4, 2018). Mrs. Dogwood indicated that this experience influenced her to intentionally try to motivate and support students of underrepresented genders and races in STEM careers: “That’s one of the things I am working on for next year is doing a STEM highlight once a week to kind of show them, you know, that there’s STEM women professionals, and there’s African American, and there’s Hispanics. There’s all these different people that do these extraordinary things.” (M. Dogwood, interview, June 4, 2018). This is an example of a *catalyst* of CRE, as Mrs. Dogwood described a direct link between her perceived positive and supportive experience at the secondary level and her desire to make sure that she encourages underrepresented races and genders in STEM fields.

Despite this support she describes from her secondary math teachers, Mrs. Dogwood also mentioned the role of her secondary school experience as an *inhibitor* of CRE. Mrs. Dogwood’s survey indicated that the secondary schools she attended were *mostly one race or ethnicity*.

When asked to explain why she had selected this option, she explained “I am from a very small rural area that was, and still is, predominantly White. In fact, there is NO diversity in race, it’s ALL White.” (M. Dogwood, Interview, June 4, 2018). In a follow-up question, Mrs. Dogwood was asked how this experience at her secondary school influenced how she teaches. In response, she stated “I feel like sometimes it’s a struggle because I can’t teach the way I was taught. Because all the kids we have here, they’re not middle class White kid like I was, like we all were.” (M. Dogwood, interview, June 4, 2018). This comment shows that the lack of diversity in her secondary school did not provide a model of educational practice that works in a more diverse setting, and as such is an *inhibitor* of Mrs. Dogwood’s ability to enact CRE in her classroom.

The role of teacher education. As with many other identified influences on Mrs. Dogwood’s CRE profile, she displayed both *inhibitor* and *catalyst* categories for her teacher preparation experience in relation to CRE. In her survey participation, Mrs. Dogwood indicated that she recalled *frequent* discussions of race and culture in STEM content or teaching methods classes she took. However, when asked if her experiences in her teacher education program influenced her teaching style or philosophy in relation to CRE, she stated “No, but I feel like it’s hard for teacher prep classes to prepare you for actually teaching this way. They can give you a strategy or one individual lesson idea but no two days are the same, no two years are the same” (M. Dogwood, Interview, June 4, 2018). This statement shows an *inhibitor* of CRE as Mrs. Dogwood could not recall a positive impact or influence from her teacher education program in relation to culturally relevant STEM education.

On the *catalyst* side, she stated that her teacher preparation program “opened my eyes to *differences being OK*. And I’ve continued to learn this over the years, it’s that everyone has

different needs and you have to meet those needs differently” (M. Dogwood, interview, June 4, 2018). Especially given her experience at a secondary school void of racial diversity, this comment shows that Mrs. Dogwood’s teacher preparation program *catalyzed* her ability to be culturally competent in her teaching.

Summary. The CRE profile for Mrs. Dogwood displays 100% *developing* or *proficient* categorizations in both Academic Skills and Concepts as well as Cultural Competence. While she does display *undeveloped* codes in the realms of Critical Reflection and Critique of Discourse of Power, Mrs. Dogwood also displays both *developing* and *proficiency* in these areas as well, suggesting the potential for more learning progressions in these areas. Mrs. Dogwood talked about multiple influences in relation to her CRE profile. Of these influences, the role of building and maintaining relationships with students was identified as a *catalyst* of CRE. The role of her current school/teaching context emerged largely (90%) as an *inhibitor* of CRE. The remaining influences on Mrs. Dogwood’s CRE profile: community, technology, secondary education, and her teacher preparation experience, displayed both *catalyst* (66.7%-75%) and *inhibitor* (25%-33.3%) qualities in relation to CRE.

Mr. Redbud

The second focus case for this study is Mr. Redbud. Like Mrs. Dogwood, Mr. Redbud teaches seventh grade mathematics at Forestland Middle School in Green Valley County. The publically available data for both Forestland Middle and Green Valley County, providing context to Mr. Redbud’s current teaching context, are found in Mrs. Dogwood’s focus case story (Table 5, Table 6). Although Mr. Redbud and Mrs. Dogwood teach at the same school, these participants have a different context for teaching within the same building. The school operates on a “teaming” environment, where students are placed into “team” groups based on individual

academic achievement characteristics. This arrangement can be somewhat of a scheduling necessity, to make sure that students receive the services that they are entitled to. Additionally, the school uses this arrangement to arrange their support each individual students learning needs. Mr. Redbud's "team" is responsible for the instruction of students who receive English language learner services and students with individualized education plans.

Mr. Redbud is not originally from the geographic region where this research takes place; he attended secondary school and a teacher preparation program in the Midwest region of the United States. After receiving his Bachelor's in Elementary Education, Mr. Redbud has taught multiple subjects and grade levels, including elementary grades, middle school math, and high school math. Before moving to the location of this research, Mr. Redbud earned his Master's in Education while he concurrently taught school. Mr. Redbud even became licensed and served as an administrator for a few years before deciding to return to the classroom to teach secondary math. About 10 years ago, he decided to officially become certified to teach all mathematics courses in secondary grades, and also achieved the status of a National Board Certified Teacher.

Mr. Redbud's Survey Participation. Full survey responses for Mr. Redbud are presented in Appendix F, and the specific survey responses that led to Mr. Redbud's selection as a focus case are presented here. In his survey, Mr. Redbud indicated that the secondary school he attended was *diverse*, he *strongly agreed* that teachers encouraged awareness of social issues affecting culture, *strongly agreed* that he learned about how race and ethnicity can play a role in who is successful, and *often* remembered talking about social justice or equity in a STEM class. Regarding his teacher preparation program, Mr. Redbud recalled this experience being *diverse*, he *strongly agreed* that faculty encouraged awareness of social issues affecting culture, *strongly agreed* that he learned about how race and ethnicity can play a role in who is successful, and

sometimes remembered talking about social justice in STEM courses. When asked about his current school teaching context, Mr. Redbud indicated that his school *sometimes* provides opportunities about social justice. When asked about the STEM classes he teaches, Mr. Redbud responded that issues of race and culture are being taught and discussed *sometimes*, that he believes race and culture play a role in STEM education *sometimes*, and that he and his students talk about social justice and equity in his STEM class *sometimes*. Following each segment of the survey was an optional free-response question for comments: after the questions asking about the STEM classes that he teaches at his school, Mr. Redbud commented “room to grow.” (M. Redbud, Survey, April 23, 2018).

Mr. Redbud was selected to participate in a follow-up interview based on the following:

- 1) Mr. Redbud indicated on his survey that he has been teaching for 25 years, and was selected for his participation in this study to provide representation of an experienced educator in this group of focus cases.
- 2) Mr. Redbud indicated that both his secondary experience and teacher education experience provided opportunities to learn about race, culture, social justice, and equity, and that some of this learning was in relation to STEM courses, and
- 3) Mr. Redbud’s comment that he has “room to grow” regarding how race, culture, social justice, and equity are presented in his STEM class indicates an inclination towards CRE, even though he did not report *often* or *frequent* use of culturally relevant STEM education.

Mr. Redbud's CRE Profile. While all tenets of CRE were discussed in his interview, Mr. Redbud described his conception of and efforts on enacting the CRE tenet of Cultural Competence most frequently (36.1%), as seen in Figure 14:

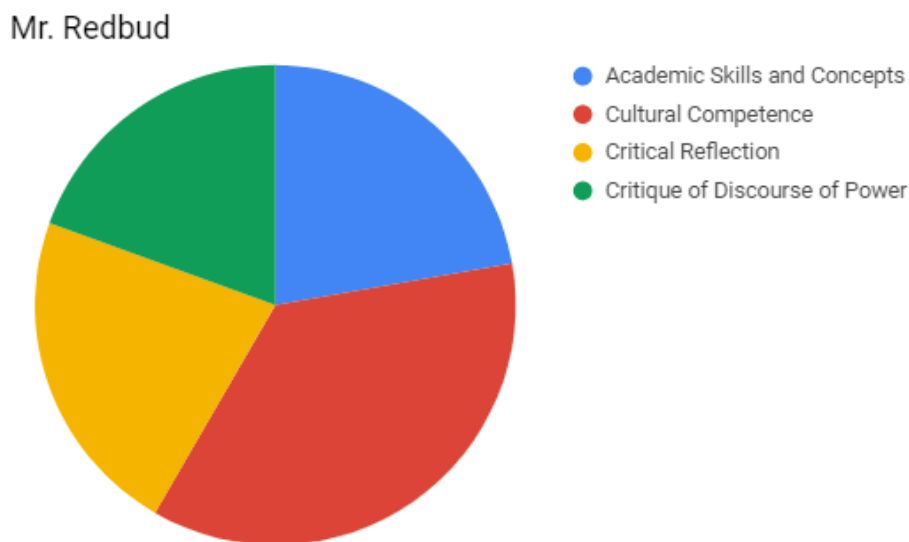


Figure 14: Mr. Redbud's Expressed Tenets of CRE

Figure 14 shows the classification of comments in relation to the four tenets of CRE. While the sophistication levels interview data were coded for all participants as *undeveloped*, *developing*, or *proficient* according to the rubric found in Table 4, Mr. Redbud did not show an *undeveloped* categorization for any of the tenets of CRE. Therefore, as seen in Figure 15, Mr. Redbud's proficiencies in relation to the tenets of CRE displays only *developing* and *proficient* categorizations.

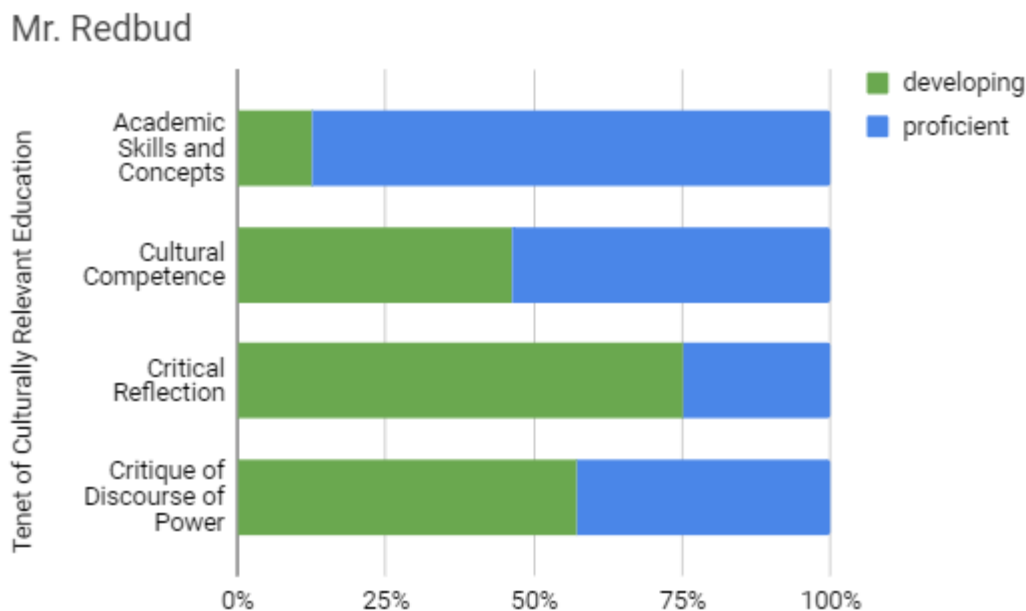


Figure 15: Mr. Redbud's CRE Sophistication Levels

Academic Skills and Concepts. Mr. Redbud's *proficient* categorizations for Academic Skills and Concepts represented 87.5% of his comments on this topic. When asked if he sees predictors of academic outcomes in his classroom, Mr. Redbud talked of the difference between what the students can do and what they believe they can do, and his role in getting them to realize that they can actually do much more than they believe they are capable of: "It's more about what they think they can do than what they can actually do. It's kind of like they've been programmed to think 'I'm not good at math' or 'I'm not supposed to do math,' that kind of thing. And you have to build them up to believe that they can do it" (M. Redbud, Interview, June 4, 2018). His motivational factors included allowing students to experience academic success: "That's sometimes based on how they perceive school. Is it a place where they want to come and do well at, or is it a place where they've always been frustrated? We start by providing small successes, and it snowballs from there, and then we get big success stories" (M. Redbud,

Interview, June 4, 2018). These comments relate to a *proficient* level of Academic Skills and Concepts as the teacher is assuming responsibility for academic success and student learning.

When asked how he approaches a student that he feels is underperforming in his class, he stated: “Remediation! It depends in the kid, and what level they are at, and what the real issue is. Once you figure that out, you go to where they are academically” (M. Redbud, Interview, June 4, 2018). This comment again shows *proficiency* in relation to Academic Skills and Concepts as Mr. Redbud indicated his willingness to vary instruction and assessment to support academic success, based on student needs.

When asked to what extent his knowledge of students’ backgrounds impacts his lesson planning, Mr. Redbud responded “that’s a big part of it. . . any kid can do well, you just have to figure out how to give them that pathway” (M. Redbud, Interview, June 4, 2018). This comment was also demonstrative of a *proficient* level of Academic Skills and Concepts as it shows Mr. Redbud’s belief that all students can, and need to, experience positive academic outcomes in the STEM classroom.

Cultural Competence and Critical Reflection. Cultural Competence and Critical Reflection are discussed congruently for Mr. Redbud, as many of the comments he made on these topics referenced both tenets of CRE at the same time, in the same context. For Cultural Competence, Mr. Redbud displayed 50% *proficiency* and 50% *developing* categorizations. For Critical Reflection, Mr. Redbud displayed 75% *developing* and 25% *proficient*.

Mr. Redbud described classroom learning where students interacted with the tenets of Cultural Competence and Critical Reflections through the personalized learning model that he uses. Personalized learning leverages available classroom technology to help differentiate instruction across both ability levels as well as student interests. Additionally, personalized

learning allows students to work towards mastery at their own pace, reducing the emergence of gaps in learning that can occur with more linear models of presenting instructional content.

Personalized learning is also centered on project-based learning; students are not simply watching videos and completing worksheets tailored to their ability level and interests; they are creating, exploring, and problem-solving relevant topics related to the standards and concepts they are learning. Mr. Redbud describes his use of personalized learning in the following manner: “Am I where I want to be with Personalized Learning? No. But I’m slowly trying to bring those things [culture, race, student lived experiences] in, and a lot of that work centers on conversations with kids” (M. Redbud, Interview, June 4, 2018).

Through this personalized learning model, Mr. Redbud described a unit of study based on proportions (Learning Standard: Recognize and represent proportional relationships between quantities, and use proportional relationships to solve multi-step ratio and percent problems). In this unit, Mr. Redbud introduced the concept to students by reading aloud the children’s book *If the World Were a Village* (Smith & Armstrong, 2011). This book scales world populations, demographics, and resources down to 100 people and presents the data through what is effectively a mathematical scale model. An example from the book states that if the world were a village of 100 people, “21 speak a Chinese dialect – of these people 16 speak the Mandarin dialect; 9 speak Hindi, 9 speak English, 7 speak Spanish, 4 speak Bengali, 4 speak Arabic, 3 speak Portuguese, 3 speak Russian. If you could say hello in these eight languages, you could greet well over half the people in the village” (Smith & Armstrong, p. 10, 2011). Mr. Redbud described “just reading something like this is a simple way that kids can see themselves, see where they come from or where they have been, especially if they come from another country or

culture” (M. Redbud, Interview, June 4, 2018). This shows a *proficiency* in Cultural Competence as Mr. Redbud identified how cultural issues can be integrated into math classroom instruction.

The starting point of this unit of study is introducing proportions in the context of globalism and multiculturalism, and next, Mr. Redbud has students do their own investigation into a culture or geographic region, related to their personal interest or background, using the same proportional model presented in the book. These investigations provide a relevant context to present and practice the mathematical concepts required by the proportion standards (ratios, percentages, unit rates/constant of proportionality), as well as demonstrate this understanding in multiple ways (verbally, and through charts, graphs, and diagrams) also as required by the standards. Mr. Redbud provided this example: “So, looking at the percentage of a population that has access to clean water, then you start talking about those who don’t [have access to clean water]. And you talk about what does that really mean? Why do they not have clean water?” (M. Redbud, Interview, June 4, 2018). This comment shows a *proficiency* in both Cultural Competence and Critical Reflection, as Mr. Redbud describes students being engaged in a critical examination of a cultural topic that relates directly to mathematics instruction.

In addition to these meaningful conversations, Mr. Redbud gave a couple of examples of student-led projects that originated from this unit of study, such as organizing a food drive after students gained mathematical understanding of how many people both worldwide and locally go to bed hungry each night. An additional example: after learning about how many children do not have an adult who can read to them at home, students organized after-school reading groups where the middle school students went to the nearby elementary to read to students in the after-school program. Mr. Redbud states that not every student makes this association between learning about an issue and wanting to address that issue in the real world, and he wants to

increase student participation in that realm of the project: “we want to attack more personal issues. It can be a positive or a negative issue, but something they are interested in, so that’s the goal this year, is to pull more of this out of them, so that they can bring whatever they want into it . . . we’ve gotten to where we can teach critical thinking within the subject, but we haven’t expanded it past that [for all students], and that’s hopefully my goal for next year” (M. Redbud, Interview, June 4, 2018). These comments show a *developing* level of Cultural Competence and Critical Reflection as while plans are being made for integrating this into classroom STEM instruction, the integration is not yet finalized or implemented.

Critique of Discourse of Power. Mr. Redbud’s Critique of Discourse of Power profile shows 42.9% *developing* and 57.1% *proficient* categorizations. When asked if he feels that issues of power and inequity have a role in today’s math and science classrooms, Mr. Redbud stated that issues of power and inequity are “less than it was, but it’s still there” (M. Redbud, Interview, June 4, 2018). He brought up the example of looking at the pictures in his math textbook: “You look and you see pictures now, there's usually three people in the picture now, and it's a pretty diverse three people, but if you look at the person clearly in the lead, he's still a White male. But, there's diversity in the picture now when there wasn't any diversity before. It used to just be the three White guys. But the White male is still clearly in the lead, and the kids see that, so we gotta talk about it” (M. Redbud, Interview, June 4, 2018). This comment represents a *proficient* categorization of Critique of Discourse of Power as Mr. Redbud identifies an issue of power and equity in the STEM classroom and mentions addressing it with his students.

In his continued response to the same question about the role of power and equity in STEM classrooms, Mr. Redbud stated “you can’t take away the outside influences, we can’t change that . . . well, we can’t change it very much. But it is changing. Honors classes aren’t just

White boys anymore” (M. Redbud, Interview, June 4, 2018). This observation shows a *developing* level of Critique of Discourse of Power, as Mr. Redbud is clearly examining a societal power structure, but does not present that he does this critique with students as a part of STEM learning.

Catalysts and Inhibitors of Mr. Redbud’s CRE Profile. Mr. Redbud’s interview data were also analyzed for the influential themes that emerged in relation to culturally relevant STEM education. The themes identified in Mr. Redbud’s data were the role of relationships, the role of the current school setting, the role of the surrounding community, the role of family, the role of technology, the role of secondary education, and the role of the teacher preparation experience. Figure 16 shows the relative distribution of discussing each theme in relation to CRE in Mr. Redbud’s interview. Following the identification of these themes, each was additionally categorized as a *catalyst* or *inhibitor* of CRE. Figure 17 shows the tendency of each theme to be wither a *catalyst* or an *inhibitor* of Mr. Redbud’s ability to enact CRE in his classroom

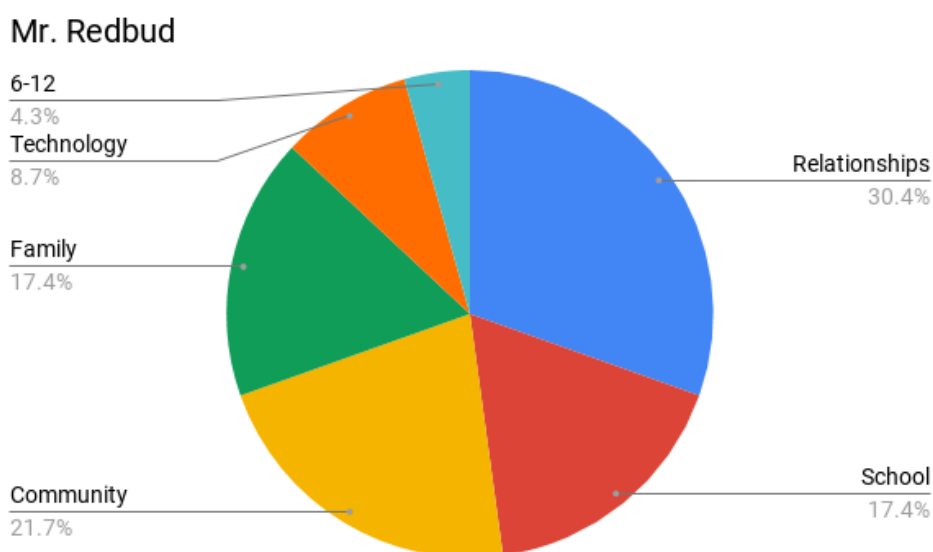


Figure 16: Influences on Mr. Redbud's CRE Profile

Mr. Redbud

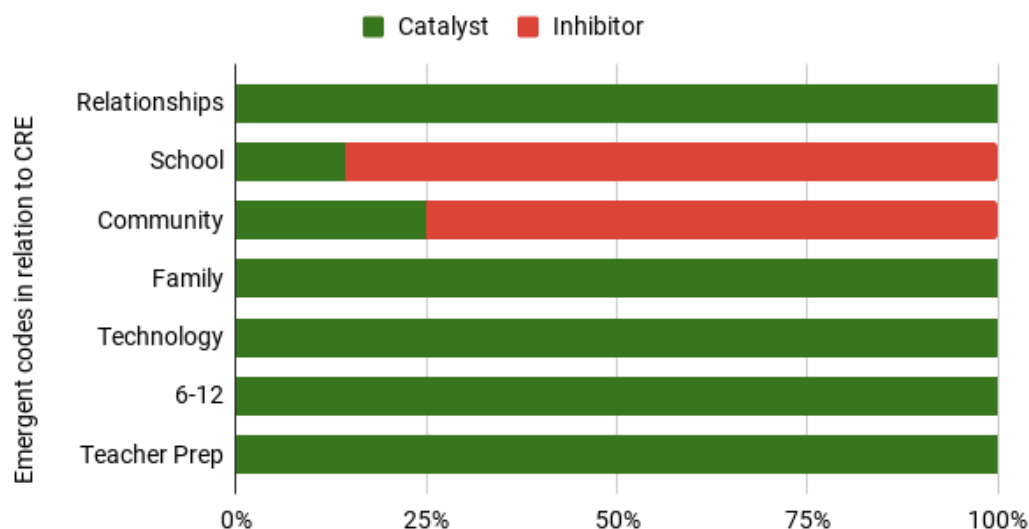


Figure 17: Catalysts and Inhibitors of Mr. Redbud's CRE Profile

The role of relationships. During the interview, Mr. Redbud talked most frequently (30.4%) to the role of relationships in creating a classroom environment able to implement CRE. Additionally, his mentions of the role of relationships play with regards to CRE are all *catalysts*. When asked how he makes sure he is meeting the academic needs of all the students in his classes, Mr. Redbud responded “The first thing is getting to know these kids. That’s where it all starts” (M. Redbud, Interview, June 4, 2018). This shows that Mr. Redbud uses his relationships with students as a *catalyst* to support their Academic Skills and Concepts. In response to the same question, Mr. Redbud continued: “It’s figuring out their personality, their background, what drives them to do well, what motivates them. Get to know them personally, and then you go to where they are academically, but all that is based on who they are as a person” (M. Redbud, Interview, June 4, 2018). This comment shows that Mr. Redbud uses his relationships with student as a *catalyst* of both Academic Skills and Concepts and Cultural Competence, as he

describes his knowledge of students, including personal or background knowledge, being used to support academic success.

The role of school. Mr. Redbud was critical of his school and fellow teachers in relation to CRE, as 87.5% of his comments about the role of the school in relation to CRE were classified *as inhibitors*. When prompted to discuss how he approaches a student who is not meeting his expectations, Mr. Redbud explained “If it is a kid who is maybe not connected to the school I try to spend some time to get them to realize that they belong there. They’re going to act out because they don’t want to be there because they’re not doing well.” Mr. Redbud describes the school as an *inhibitor* of Academic Skills and Concepts, as the school culture described by Mr. Redbud is not conducive to the student experiencing academic success.

When asked if the teachers and principals at his school seem to value diversity, he responded: “Some. Some do. I think it is definitely something we need to work on as a school. I don’t think we have an outright, like, hey – we don’t like this group or that group, but I do think that we don’t know how to work with groups different from ourselves. And you know a lot of it is just being around different people than yourself, and broadening those expectations, and we don’t do that as a school. We have a workshop on one day that’s supposed to change your life. And it doesn’t. It’s a change process, and it takes time” (M. Redbud, Interview, June 4, 2018). This comment showed that the school *inhibits* staff Cultural Competence, as Mr. Redbud notes the existence of implicit bias, and that this is not being addressed or confronted in a way that he believes to be effective.

The role of community. Mr. Redbud’s comments regarding the surrounding community as an *inhibitor* of CRE were largely in comparison to his experiences teaching in a different state in a different geographical region, as opposed to teaching in his current setting. He mentioned

multiple times how the surrounding community does not seem to value education in general, much less value cultural relevance in education, in comparison to his previous teaching context and surrounding community. Following a description of multiculturalism at one of his previous schools, Mr. Redbud stated “and then I came to [the Southeast region]. And you know, things are just different here” (M. Redbud, Interview, June 4, 2018). This is an example of the surrounding community being an *inhibitor* of Cultural Competence as Mr. Redbud indicated that he does not feel that his current community values or supports multiculturalism like his previous teaching context did.

The role of family. Mr. Redbud discussed family as a *catalyst* (100%) of his use of CRE in the classroom, both his personal family experiences as well as the potential for the families of his students to support CRE if given the proper support. When asked about his motivations towards multiculturalism in the classroom, he commented: “So, my parents, we worked with Children’s Church back in the old days, back in the 70s. That was one of my first multicultural experiences, because we had kids from everywhere in there. That was something my parents taught me from the beginning, is to welcome everybody and celebrate everybody. They were like ‘Okay, we’re going to meet a lot of kids today, that don’t look like kids in our neighborhood, and we’re going to have fun talking to them and learning about where they come from.’ And it *was* fun. So I would say my parents very much influenced me in that way” (M. Redbud, Interview, June 4, 2018). This discussion demonstrates that Mr. Redbud’s family played an influential and *catalyzing* role in his ability to be culturally competent.

When asked about stakeholders that could play a role in supporting CRE, specifically the student acquisition of Academic Skills and Concepts required for CRE, Mr. Redbud described designing and implementing a Parent University concept at his school. “With math, a lot of

parents say, ‘well I don’t remember that’ or ‘I’ve never learned that.’ So we try things like Parent University, where we hold times where parents come in and learn the math that they can use with their kids. And we make YouTube videos of this, so if parents can’t be there, they can still get the information. And then we see parent buy-in, which helps with parents helping their kids, which helps with student buy-in” (M. Redbud, interview, June 4, 2018). Here, Mr. Redbud is describing how, with a little help, parents and teachers can partner as *catalysts* to ensure students are acquiring Academic Skills and Concepts.

The role of technology. All of Mr. Redbud’s mentions of technology indicated that technology was a *catalyst* of his ability to enact CRE in his classroom. In addition to the quote above about using technology to engage family members via YouTube videos created at Parent University, Mr. Redbud also spoke to technology as a *catalyst* of CRE in his classroom in other ways. In response to multiple interview questions, he often referenced the personalized learning model made possible by the presence of individual (1:1) technology resources in his classroom. “The way we’ve got it set up right now, they [the students] have everything on their Chromebooks. Basically they are in charge of their own learning, and if they fail they know it instantly that they failed or they don’t get a concept, so they immediately turn to what can I do to get better. They take more ownership, and I think that’s the best part of personalized learning” (M. Redbud, Interview, June 4, 2018). Here, Mr. Redbud is describing the potential of technology to *catalyze* student’s academic success through ownership of their learning.

Role of secondary school experience. Mr. Redbud describes his secondary school experience as a catalyst (100%) of CRE. When asked about his survey response that indicated that the secondary school he attended was *diverse*, Mr. Redbud elaborated “It was designed to be a multicultural experience. They made sure that you met all kinds of different kids from the first

day you got there. I came late, in October, and they had a whole variety of kids to meet me, so you felt like they wanted to include you in everything, and that was well done by the school. The school really did a good job at that, I was very impressed with that. So I think that's where I started thinking that I wanted to teach school and that I wanted to teach in more of a city environment than a country environment, even though I come from the country environment. I had some excellent teachers at that high school...they were just the best teachers. They were loving and kind and really good at their job" (M. Redbud, Interview, June 4, 2018). This discussion shows that Mr. Redbud's secondary school experience not only *catalyzed* him to enter the teaching profession, but additionally provided a model for him to think about enacting Cultural Competence into his teaching practice.

The role of teacher education. As with many of the emergent themes in Mr. Redbud's interview, he described the role of his teacher education experience as a *catalyst* (100%) of his ability to enact CRE in his classroom. Mr. Redbud attended a traditional teacher preparation program, and described his teacher preparation as follows: "I have to say that I probably had one of the best teacher education experiences in the world. When I compare it to what I hear other [new teachers] talk about now...I mean, this was back in the 80s. We were doing things then that is just now being heard of in other places, just now becoming common. You talk about multicultural education, we were doing that and learning that way back in the 80s, and that was a huge part of the program. I mean, it wasn't labeled that. It was, you know, like these are different kids and these are different cultures and these are different knowledges and these are different ways of learning. We were doing that way back then" (M. Redbud, Interview, June 4, 2018). This comment shows that Mr. Redbud feels like his teacher preparation helped encourage and

demonstrate the importance of Cultural Competence, thus being a *catalyst* of his ability to enact CRE in his STEM classroom.

Summary. Mr. Redbud's data describes an experienced educator with multiple and varied experiences that have influenced his learning progression toward enacting CRE in his secondary math classroom. These influences have resulted in him not displaying any *undeveloped* categorizations for any of the tenets of CRE; he displays 100% *developing* or *proficient* levels of sophistication in all areas of CRE. Mr. Redbud's data shows that there are multiple factors that both *catalyze* and *inhibit* his ability to enact CRE in his STEM classroom. While he describes both *catalyst* and *inhibitor* roles for his current teaching context, he believes the role of the school is more of an *inhibitor* (85.7%) than it is a *catalyst* (14.3%). Additionally, the role of the surrounding community is more of an *inhibitor* (75%) than *catalyst* (25%) of CRE. However, all of the other themes identified in relation to CRE (relationships, family, technology, secondary education, and teacher education) were identified as 100% *catalysts* of CRE for Mr. Redbud.

Mrs. Clover

The third focus case in this study is Mrs. Clover. Mrs. Clover teaches 6th and 7th grade science at Meadows Middle School in Green Valley County. Meadows Middle is almost 20 miles away from Forestland Middle, but still in Green Valley County. Meadows Middle is located in an affluent suburban area of the county. The demographics of the student population shift in a predictable manner from those found at Forestland: Meadows Middle is almost 85% White, 8% Black, 5% Latino, and 2% Asian. Less than 2% of students at Meadows Middle receive services for English language learners. Less than 9% of students at this school have an

individualized education plan, and less than 10% of students at this school receive free or reduced lunch.

Meadows Middle is an active participant in county-wide competitions, and their STEM Club, Robotics Club, and Concert Band frequently bring home prizes and accolades. The school website features multiple news articles from these and other public recognitions related to their school academics and extra-curricular activities. Additionally, Meadows Middle received the second-highest ranking given by the state Department of Education for school-wide growth and achievement as measured by mandatory student standardized test performance.

Mrs. Clover has only been teaching at Meadows Middle for one year. She taught in Green Valley County previously, then moved to a different state for several years, and then her family moved to Green Valley County last year. She has been teaching for eight years total, in two states, three districts, and five different schools. This experience includes teaching at an urban middle school in Green Valley County that showed demographics quite different than that from Meadows Middle.

Mrs. Clover's Survey Participation. Mrs. Clover was selected to participate as a focus case for a follow interview based on her survey results, and a full account of her survey responses is found in Appendix E. In her survey, Mrs. Clover indicated that the secondary school she attended was *mostly one race or ethnicity*, and that issues of race, culture, social justice, and equity were *never* or *seldom* taught or discussed in STEM classes. While she indicated that her teacher education experience had more diversity than her secondary experience, she reports that issues of race, culture, social justice, and equity were *seldom* discussed in a STEM course. When asked about her own STEM classroom and teaching practice, Mrs. Clover indicated that she *often* or *frequently* teaches or discusses issues of culture, and *sometimes* teaches or discusses

issues of race, social justice, and equity. Mrs. Clover was selected to participate further in this research as a focus case based on the following criteria:

- 1) Mrs. Clover's eight years of teaching experience, and the multiple contexts in which she has taught, allows for many influences in relation to CRE to have emerged,
- 2) Despite a lack of focus on these topics at both the secondary level and the teacher preparation level, Mrs. Clover reports that she *sometimes* or *often* enacts aspects of CRE in her STEM classroom. This provides the opportunity to explore her CRE profile and the influences that have impacted her implementation of aspects of CRE.

Mrs. Clover's CRE Profile.

Mrs. Clover

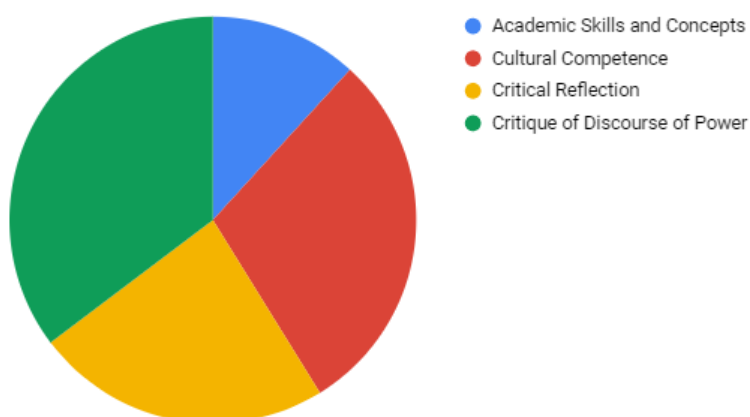


Figure 18: Mrs. Clover's Distributions of CRE Tenets

Figure 18 shows the relative distributions of the tenets of CRE that Mrs. Clover discussed during her interview, and Figure 19 shows Mrs. Clover's sophistication levels, classified as *undeveloped*, *developing*, or *proficient*, for each tenet of CRE.

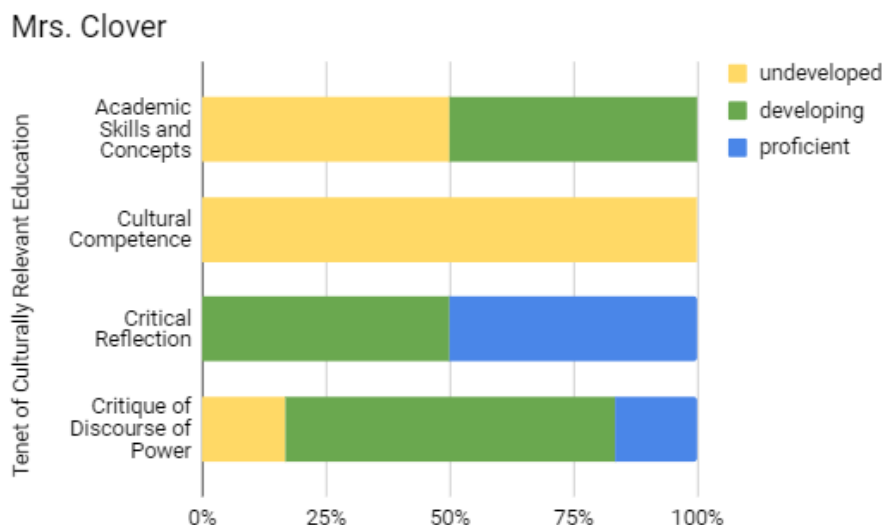


Figure 19: Mrs. Clover's Proficiencies in Relation to the Tenets of CRE

Academic Skills and Concepts. Mrs. Clover's profile in relation to Academic Skills and Concepts shows that 50% of her comments were categorized as *undeveloped* and 50% of her comments were categorized as *developing*. When asked if there are predictors of academic outcomes for the student in her classes, she stated "you just have some kids that you just knew, no matter what you did, they weren't going to try and were going to fail" and "so the kids that were low, I knew they were going to stay low" (M. Clover, Interview, June 22, 2018). This shows an *undeveloped* level of Academic Skills and Concepts as Mrs. Clover does not appear to be taking responsibility for the academic outcomes of her students, and does not demonstrate that all students are capable of acquiring key academic skills.

When asked how she makes sure that she is meeting the needs of all students in her classroom, one of Mrs. Clover's comments included "What happens with teachers is we're told that everyone has to achieve and be proficient, and it's just an impossible goal. If the kid is a zero, and I get him to a 15, that's growth" (M. Clover, Interview, June 22, 2018). While the growth portion of this comment is factually accurate, and while this comment shows some

ownership of the teacher's role in ensuring academic success for her students, a student with a 15 is unlikely to be experiencing academic success or mastery of skills and concepts. For these reasons, this comment was also categorized as *undeveloped* in the area of Academic Skills and Concepts.

Talking further on the interview prompt related to what she does to make sure she's meeting the needs of all students in her classes, Mrs. Clover did describe some *developing* levels of Academic Skills and Concepts. She stated that "I don't go home each night and plan like 'Okay, for tomorrow, I'm going to . . .' it's pretty much on-the-fly happening in my room, but if we don't get a concept we say, 'so, we gotta go back and do this again' It's that sort of thing, but it's not necessarily planned out" (M. Clover, Interview, June 22, 2018). This was classified a *developing* conception of Academic Skills and Concepts as Mrs. Clover appears to be allowing for some flexibility to meet her students' academic needs, but this is not explained explicitly, or integrated as a part of a classroom policy.

Cultural Competence. Mrs. Clover's CRE profile shows that all of her statements in relation to Cultural Competence were *undeveloped*. When asked to what extent does her knowledge of students' background influence how she plans or teaches, Mrs. Clover responded; "It doesn't because I'm teaching science. I'm teaching such content-heavy stuff that, no matter where you come from, it's the same thing. Like, mitosis only happens in a certain order, no matter if you come from a well-off family or a poor family or somewhere in-between" (M. Clover, Interview, June 22, 2018). This comment was classified as *undeveloped* as Mrs. Clover communicates that influences of a student's lived experiences, including culture, have no bearing on STEM content learning or what happens in the STEM classroom.

When asked if she can design lessons that incorporate cultural and societal issues, Mrs. Clover offered “It’s hard to draw from their own experiences, especially when you’re talking about cell organelles. You can talk about ‘well, why are you breathing?’ It’s a lot of natural things that they are doing every day, but it doesn’t have to do with their culture, if that makes sense” (M. Clover, Interview, June 22, 2018). This explanation was categorized as *undeveloped*, again based on the communicated idea that culture does not relate to or have bearing on STEM education.

An additional conversation about culture in the STEM classroom emerged when Mrs. Clover was prompted to speak to her survey response that students *sometimes* learn how race and ethnicity can play a role in who is successful at her school. She critically talked about the influence of our current, societal culture in determining who is successful and who is not, but then stated “so, with this current culture we have, I don’t think a lot of parents stop and take the time to talk to them [students], even though I feel like it’s more their job than mine. When I was growing up, school was for you to learn school stuff, and you went home and your parents taught you everything else” (M. Clover, Interview, June 22, 2018). This comment shows an *undeveloped* Cultural Competence as Mrs. Clover does not indicate an acceptance of the role of culture in the schools, nor the role of a classroom teacher in incorporating culture in to the school setting, much less the STEM classroom.

Critical Reflection. Unlike her discussions about incorporating culture in to her STEM classroom, Mrs. Clover communicated her willingness to engage in Critical Reflections with her students in the context of science instruction. None of Mrs. Clover’s descriptions of Critical Reflections were categorized as *undeveloped*; as seen in Figure 34. The Critical Reflection categorizations were evenly split between *developing* (50%) and *proficient* (50%) sophistication

levels. Some of Mrs. Clover's comments on this topic described how she includes students in these Critical Reflections, warranting the *proficient* categorization.

In a portion of her response to the interview question asking if students learn how race and ethnicity play a role in who is successful, Mrs. Clover told a story of a Black student that she developed a relationship with: "she would say the N-word, and be like 'well, I can say it, but you can't say it.' And I just asked her to speak to that, like, 'tell me more, I want to know about what this means to you' and she wouldn't respond so I'd be like 'no, I'm genuinely curious' and sometimes she would oblige me and we would talk, and other times she'd be like 'oh, Mrs. Clover, you're so silly'" (M. Clover, Interview, June 22, 2018). This demonstrates a *developing* level of Critical Reflection as it shows Mrs. Clover's willingness to engage in Critical Reflections with students, but does not show a context of STEM in the conversation.

When asked about how she approaches potentially controversial scientific concepts in the classroom, Mrs. Clover responded: "I try to talk a lot about bias and introduce what is bias. What does it look like? How do you make sure what you're reading isn't fake news, or something that's an agenda of someone, just to make money or whatever? I pretty much go through the context of that, and then pull the science out of it and look at the science, you know, the actual evidence, and we go from there" (M. Clover, Interview, June 22, 2018). This description was classified as *proficient*, as it makes reference to Critical Reflections in the context of STEM education, with student participation.

Critique of Discourse of Power. Figure 19 shows that the majority of comments (35.3%) made by Mrs. Clover during her interview related to the Critique of Discourse of Power tenet of CRE. Only 16.7% of these references were *undeveloped*, while 66.6% were *developing* and 16.7% were *proficient* (Figure 28). In her interview, Mrs. Clover made it clear that she was not afraid to

have controversial conversations with students, in the context of science education or not. A few months prior to Mrs. Clover's interview, there were two widely publicized school shootings with multiple casualties in the same geographic region as this research was conducted. Green Valley County allowed student-organized responses to these shootings. Mrs. Clover brought up this issue when she was asked if she incorporates societal issues into her science instruction:

“If I were allowed to I would. Like, with these shootings, we gave the kids the opportunity to be outraged and stand up for what they believe in, but then we weren't allowed to go and have follow-up conversations. But I broke the rules a little bit. I thought it was silly we let the kids walk out, twice, but our principal said we couldn't talk about it with them. And we were not allowed – I was going to put up our legislative representative's numbers and emails, like, and tell the kids ‘we can email them and try to make change’ - and were told [via district-wide email] not to. That we could not do any sort of political activity. I just feel like they are in middle school, and they just don't think things through. And that's understandable, but they need our help to think things through right now, and we're not allowed. I mean, they're walking out of school against gun violence and then going home and shooting each other on Fortnite. They're just not thinking this through, they need help thinking this through. So I might have broken the rules a little” (M. Clover, Interview, June 22, 2018).

This explanation was categorized as a *developing* conception of Critique of Discourse of Power, as Mrs. Clover expresses the need to discuss some societal power structures with her students, and even the willingness to do this when encouraged not to, but these learning moments were not described as taking place in the context of STEM education.

Catalysts and Inhibitors of Mrs. Clover's CRE Profile. Mrs. Clover discussed the role of relationships, the role of school, the role of community, the role of family, the role of her own secondary school experience, and the role of her teacher preparation experience in relation to her use of CRE. Figure 20 shows Mrs. Clover's distributions of the multiple influences she discussed in relation CRE, and Figure 21 shows each of these influences further categorized as a *catalyst* or *inhibitor* of Mrs. Clover's CRE profile.

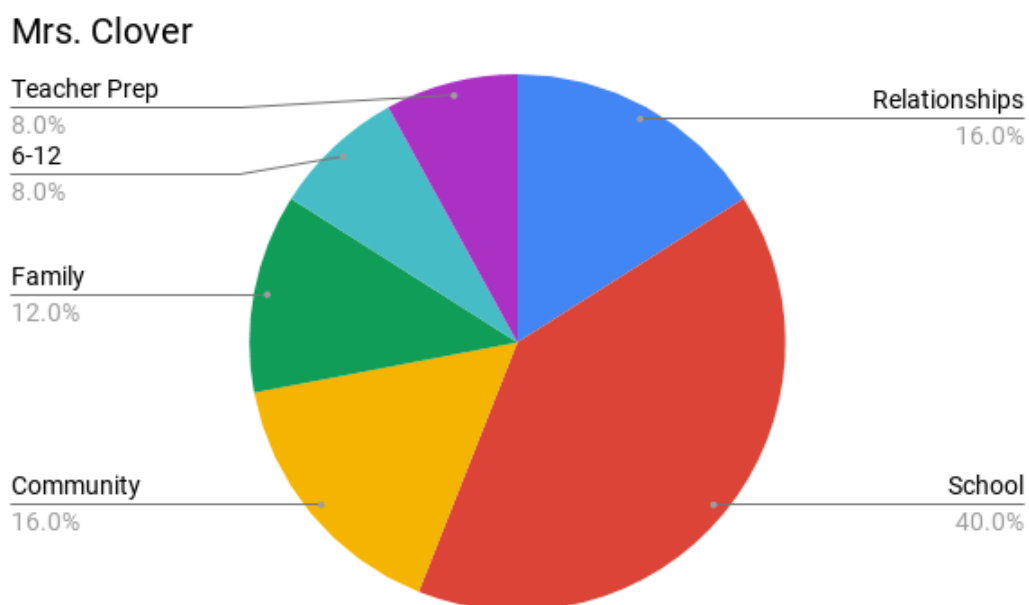


Figure 20: Multiple Influences on Mrs. Clover's CRE Profile

Mrs. Clover

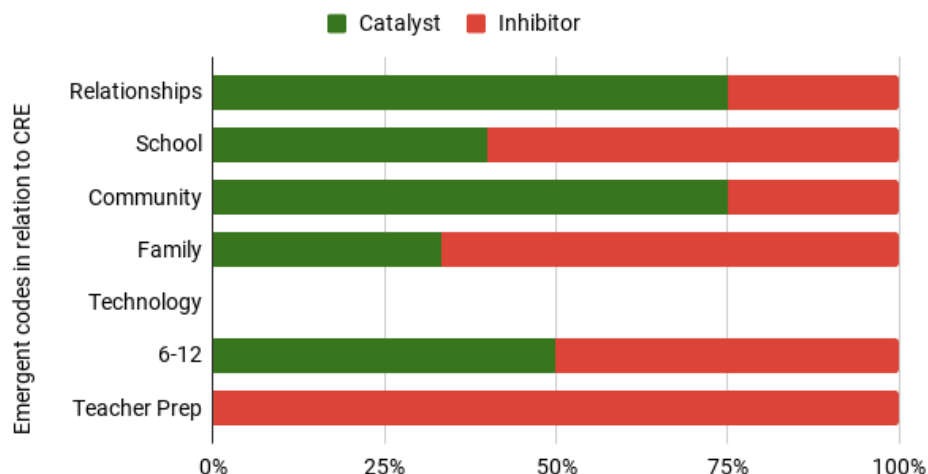


Figure 21: Catalysts and Inhibitors of Mrs. Clover's CRE Profile

The role of relationships. The majority of Mrs. Clover's references to relationships (75%) indicated they were a *catalyst* of implementing CRE in her classroom. When prompted to discuss influential moments in her teaching career, Mrs. Clover recalled her second year teaching, when she taught at what she describes as a highly challenging, urban school in Green Valley County. She remembers this experience "I wanted to succeed so badly, but I had several students that hated me, because I was a young White woman, and I remember being told in the parent meetings 'It's because you're not like us.' And my principal was like 'It's building relationships' and I was like okay, how can I make my classroom more relationship focused?" (M. Clover, Interview, June 22, 2018). She then describes her next year of teaching, after focusing her classroom instruction around building relationships, as "and that, to this day, was my best year of teaching" (M. Clover, Interview, June 22, 2018). This recollection shows that relationships were a *catalyst* of Mrs. Clover's ability to enact CRE to relate to her students and

achieve buy-in from her students in a challenging setting with students who predominantly did not share her race or cultural background.

The role of school. Mrs. Clover showed both *catalyst* (40%) and *inhibitor* (60%) categorizations of her comments about the role of school in relation to CRE. In addition to her description about the school policy *inhibiting* her ability to engage in Critique of Discourse of Power, Mrs. Clover explained other ways that school policies did not promote CRE. When asked if her current school provides opportunities to learn about social justice, she responded “yes, but I’m worried about that, because then the school has zero follow-through. They just move on to whatever the next big thing is” (M. Clover, Interview, June 22, 2018). This shows that Mrs. Clover believes the school *inhibits* Critical Reflection and Critique of Discourse of Power by not providing ample opportunity to thoroughly engage students in topics of social justice.

Mrs. Clover also mentioned the micro focus of her school on preparing students for standardized tests as an *inhibitor* of CRE. When asked what other stakeholders need to take responsibility for the academic outcomes of students, she mentioned “I think that’s the school. I think instead of just giving kids content knowledge, we have to show them, ‘what could this look like in your life?’” (M. Clover, Interview, June 22, 2018). With her perception that the focus on content knowledge is taking away from the ability to be relevant, Mrs. Clover is describing this school culture as an *inhibitor* of CRE.

The role of community. Mrs. Clover mentioned that the role of the community can both *catalyze* (75%) and *inhibit* (25%) actualizing CRE. While Mrs. Clover is originally from the same geographic region where this research takes place, she has also lived and taught in a different state. Her comments about the surrounding community being both *catalysts* and *inhibitors* of CRE were identified in her comparisons of her current teaching context with a

former teaching context. In a conversation asking if she feels like race and culture play a role in STEM education, she explained “yeah, so, I think that race is involved in kids having the opportunity to even have a STEM education here. And of course it’s not just race, it’s economic status, but a lot of times those are the same thing. There’s just not the resources here that there was in [different geographic location]. It’s great to say ‘oh yeah STEM, we’re all STEM’ but then we’ve got to put the money and resources into it, and support the teachers to do it right, and that’s just not the values or the culture of this town” (M. Clover, Interview, June 22, 2018). This account describes Mrs. Clover’s perception of how her current surrounding community *inhibits* equitable STEM education by not providing resources to enact equitable STEM education, while her previous surrounding community was a *catalyst* of this based on her perceived differences in the values of the communities.

The role of family. Mrs. Clover mentioned the role of family in relation to CRE as mostly an *inhibitor* (66.7%). Mrs. Clover’s described her own family’s needs as an *inhibitor* to her ability to enact CRE in her STEM classroom. When asked why she no longer teaches at the urban school where she reported her favorite year of teaching, she recounted a similar experience that many young female teachers experience, which is the differences in their teaching that happen should they decide to start a family of their own. Mrs. Clover explained “I used to think of my students as my kids, my children. But now. My students are still my students, but I have my own kids. I have to separate my passion for my kids, my kids at school and my kids at home. My kids at home are my number one priority” (M. Clover, Interview, June 22, 2018). While no fault or judgement can be placed for coming to this conclusion, it remains that one’s own family responsibilities can *inhibit* a teacher’s ability to enact CRE in the classroom.

The role of secondary education. While she did not talk frequently about the role of her own secondary school experience in relation to CRE, Mrs. Clover mentioned this influence as both a *catalyst* (50%) and an *inhibitor* (50%). When asked how she decided to become a teacher, Mrs. Clover describes her experience with her high school guidance counselors as follows: “I’m mad that my guidance counselors did not open my mind to any sort of science field, any sort of engineering. I was pretty much just told that you had to be good at math, and I wasn’t good at math in high school, so they were just like ‘have you considered teaching?’ and I was just like ‘Okay, I guess I’ll teach.’ But looking back, I’m honestly mad that nobody opened the world of STEM to me when I was a kid, and that’s why I try to open that world for all of my students, even if they don’t fit that typical scientist or engineer stereotype” (M. Clover, Interview, June 22, 2018). This recollection shows that although her experience at the secondary level is not one that Mrs. Clover remembers favorably, it was a *catalyst* for her to be mindful that she is providing equitable STEM education and opportunities for all of her students.

The role of teacher preparation. Mrs. Clover talked about her teacher education experience as an *inhibitor* (100%) of her ability to be a practitioner of culturally relevant STEM education. This could largely be because her teacher education program did not prepare her for secondary STEM education; she attended and received her Master’s from an elementary education program with a specialization in urban education. Mrs. Clover stated that “I felt like I was prepared to teach kids to read, but that is about it. And I don’t have to teach kids to read at this level.” (M. Clover, Interview, June 22, 2018). These *inhibitory* categorizations of her teacher preparation program might not be a function of the preparation she received, but more of a result of her not teaching in the area she was prepared to teach. However, it is important to not the

existence of this as teaching out of area in an increasing phenomenon in high-needs subjects like STEM.

Summary. Mrs. Clover's CRE profile shows 100% *undeveloped* categorizations for Cultural Competence. Her sophistication levels for Academic Skills and Concepts range from *undeveloped* to *developing*. For Critical Reflection, she displays both *developing* and *proficient* levels of understanding. With Critique of Discourse of Power, Mrs. Clover shows the full continuum of *undeveloped*, *developing*, and *proficient*. Mrs. Clover shows multiple influences on this CRE profile, and most of these influences are both *catalysts* and *inhibitors* of her level of CRE practice. She mentions the role of relationships and the role of community as being mostly *catalysts* of her use of CRE, but that the role of her current school and her family are mostly *inhibitors* of CRE for her. Mrs. Clover indicated that her teacher preparation program did not prepare her to enact CRE in the secondary STEM classroom, showing 100% *inhibitor* categorizations for her discussion of her teacher education experience.

Mr. Wildflower

Mr. Wildflower is the fourth focus case in this study. Mr. Wildflower teaches Biology to 10th through 12th grade students at Prairie View High School. Prairie View High School is situated about halfway between Meadows Middle and Forestland Middle, in an urban, metropolitan area of Green Valley County. Prairie View High serves about 1000 students, and is currently recognized by the state department of education as a school making sufficient and proficient growth and achievement scores as measured by state mandated student standardized test scores. Prairie View High has not consistently had this level of academic achievement and growth, and their dedicated staff is often credited with the increase in academic stature of the school.

The student demographics of Prairie View High are 40% Black, 20% Hispanic/Latino, and 40% White. Almost 10% of Prairie View students receive services as English language learners, and over 20% of students have an individualized education plan. Additionally, over 50% of the students at the school qualify for free or reduced lunch.

Mr. Wildflower is in his second year of teaching at Prairie View High. Mr. Wildflower grew up in the same town, but vastly different neighborhood, as Prairie View. He went to a private high school that, according to his survey participation, was comprised of *mostly one race or ethnicity*. He teaches Honors and College Preparatory biology courses, and thus has a range of students in 10th, 11th, and 12th grades. He has a Bachelor's in Microbiology, and entered teaching through a teacher preparation program that allows him to teach and earn his teaching credentials simultaneously. Resultantly, he started at Prairie View last year with no instruction in science education, but is now completing his teacher education coursework in order to earn his Masters in Science Education.

Mr. Wildflower's Survey Participation. Analysis of Mr. Wildflower's survey resulted in his selection as an interview participant. Mr. Wildflower indicated on his survey that issues of race and culture are *often* being taught or discussed in the STEM classes he teaches. Mr. Wildflower's survey results showed also that his conception of his current teaching context (*very diverse*) is quite different from his own secondary education experience (*mostly one race or ethnicity*). Additionally, Mr. Wildflower indicated on his survey that he has had one to three years of teaching experience, making him one of the most novice teachers to respond to the survey.

Based on his survey participation, Mr. Wildflower was selected for participation in the interview portion of this research for the following reasons:

- 1) His perspective as a new/novice teacher,
- 2) His experience as a teacher who comes from a background markedly different than his current teaching context, and
- 3) His responses reporting that issues of race and culture are *often* addressed in his classroom, which show an inclination towards culturally relevant STEM teaching.

Mr. Wildflower's CRE Profile. Mr. Wildflower's interview data was analyzed to create a CRE profile that establishes his proficiencies towards enacting the tenets of CRE in his classroom. First, the interview data was deductively coded for the four tenets of CRE: Academic Skills and Concepts, Cultural Competence, Critical Reflection, and Critique of Discourse of Power. Each of his comments regarding the tenets of CRE was then categorized as *undeveloped*, *developing*, or *proficient* using the rubric indicators presented in Table 4. This data analysis was used to create Mr. Wildflower's CRE profile, which is now presented and discussed.

Figure 22 shows Mr. Wildflower's frequency of discussing each of the four tenets of CRE in his interview. Mr. Wildflower frequently discussed Cultural Competence more than any other tenet of CRE, as almost half (48.1%) of his comments in relation to CRE indicated a relation to Cultural Competence (Figure 22). Centering the conversation on Cultural Competence in this way did not leave much opportunity to discuss the remaining tenets of CRE, as is seen by Academic Skills and Concepts and Critical Reflection each representing 18.5% of CRE codes. Critique of Discourse of Power was rarely discussed by Mr. Wildflower, even when prompted by interview questions, and accounts for only 14.8% of his mentions of the tenets of CRE. Figure 23 shows Mr. Wildflower's percentage of *undeveloped*, *developing*, and *proficient* categorizations for each of the tenets of CRE. This shows the majority of Mr. Wildflower's categorizations, across all tenets of CRE, to be in the *developing* category.

Mr. Wildflower

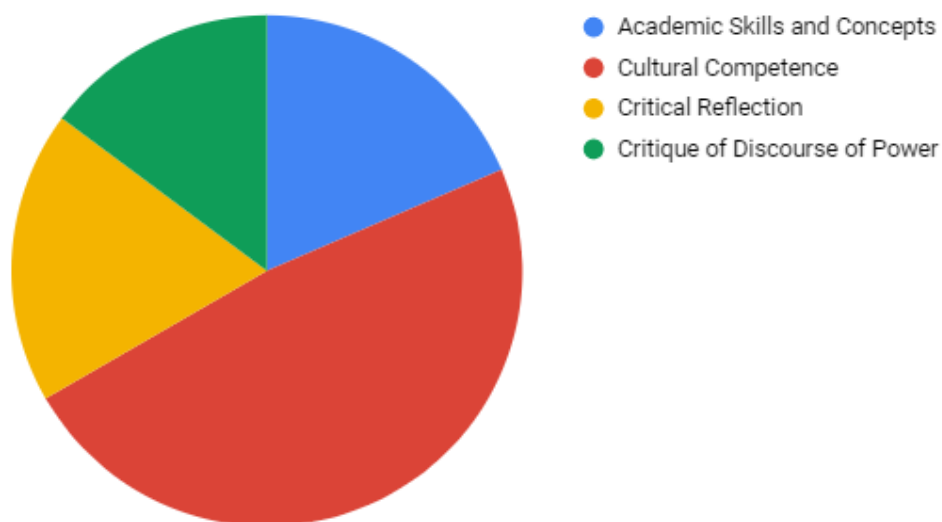


Figure 22: Mr. Wildflower's Mentions of the Tenets of CRE

Mr. Wildflower

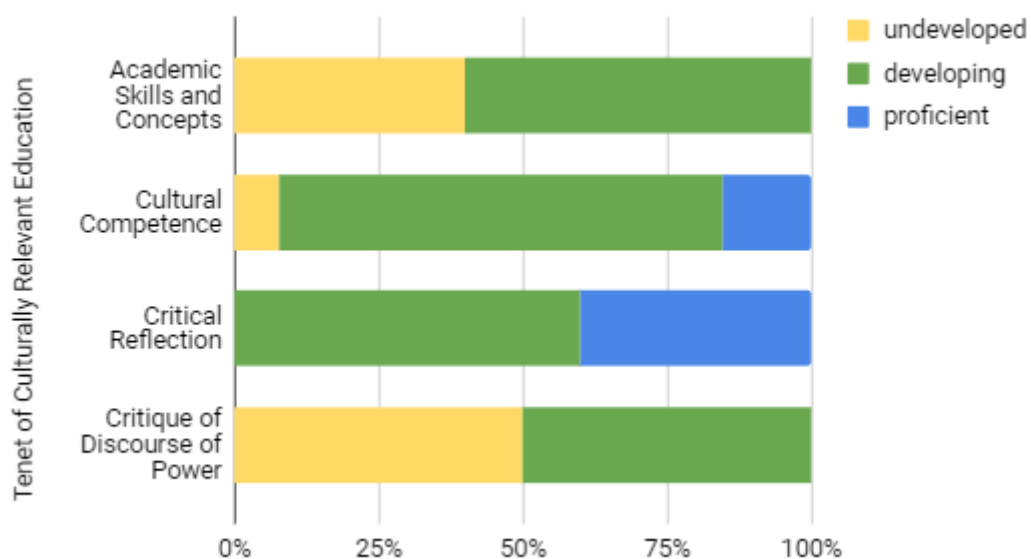


Figure 23: Mr. Wildflower's Proficiencies in Relation to the Tenets of CRE

Academic Skills and Concepts. While the majority of categories in the Academic Skills and Concepts were developing (60%), Mr. Wildflower also communicated some *undeveloped* understandings of this concept (40%). When asked what happens in his classroom when a student fails a test, Mr. Wildflower said “it depends on why they failed. Did they cheat? Did they refuse to take it? If they did that, they will get a zero. If a kid tried his hardest and had been working with me for weeks or something and still failed most likely I’d let them retake it for half points or something, depending on the situation” (M. Wildflower, Interview, June 12, 2018). This shows an *undeveloped* categorization of Academic Skills and Concepts because a Mr. Wildflower is demonstrating some flexibility and some responsibility for student learning, but the focus on both when the learning occurs and how the learning is demonstrated does not describe the actual acquisition of knowledge or skills.

When asked how he approaches students that he believes to be underperforming in his class, he replied “I just try to motivate them. In a personal way. It depends case by case. If a kid is completely resistant and doesn’t want anything to do with me, and they've got hard things going on so that they don't really worry about school, I try to utilize the counsellors and our behavior support and try to do restorative practices to try and figure out the best way to bring them back in and support their grades. If a kid is trying really hard and has no support at home I try alternative assignments or afterschool tutoring, basically just anything I can to help them” (M. Wildflower, Interview, June 12, 2018). This represents a *developing* status of Academic Skills and Concepts as Mr. Wildflower is showing some flexibility and ownership surrounding student learning, but the focus is still on completion of events rather than on the acquisition of skills and concepts.

Cultural Competence. Mr. Wildflower showed all proficiency levels for Cultural Competence, although *developing* was the largest category with 79% of discussions of Cultural Competence in the STEM classroom classified as *developing*. Mr. Wildflower described an impactful moment during his first year, when he was really struggling as a first year-teacher and then realizing that he was starting to make an impact with students: “I was sinking, sinking hard my first fall. But then I started to see these kids, even though they come from a different culture, they bought in and welcomed me into their culture. And that influenced the culture in the classroom, building that culture and developing that culture and taking that culture and using it for a positive way. I was like, wow, this is really cool, just something I've never seen before in a school” (M. Wildflower, Interview, June 12, 2018). This shows a *developing* level of Cultural Competence as Mr. Wildflower clearly notes the importance of culture in both his and his students sense of belonging in the classroom, but he does not directly relate this to STEM learning.

When asked if he can design and enact lessons that incorporate cultural or societal issues, Mr. Wildflower explained “yeah, I mean I do it most days, and it even if it's like a lesson that's hard to do that with. I usually incorporate it somehow into the warm-up to get them talking, and then we can segue into a scientific phenomenon that relates to the culturally relevant thing we talked about. Or not, I mean, it's a 90-minute block so not every moment needs to be about science” (M. Wildflower, Interview, June 12, 2018). Again, this shows a *developing* level of Cultural Competence because Mr. Wildflower talks about the importance of culture in the STEM classroom but possibly struggles to integrate this into STEM-specific learning.

Critical Reflection. Mr. Wildflower did not show any *undeveloped* categorizations for the realm of Critical Reflection, only *developing* (60%) and *proficient* (40%). When asked how

he addresses some scientific concepts that can also be politically charged, such as climate change, he stated “I know of some teachers that just say oh no, I can't teach them about this. And I'm like no, we're here to teach them about it, were telling them the content and they have to take it and run with it and explore. And these discussions are fun, too, because some of the kids have their opinions and we will get some good argumentation going on, so I really enjoy teaching controversial topics.” (M. Wildflower, Interview, June 12, 2018). This is an example of a *proficient* categorization of Critical Reflection as Mr. Wildflower describes students engaging in critical discussions about topics that are both scientific and political.

When Mr. Wildflower was prompted to discuss how he makes sure he was meeting the needs of all the students in his classroom, he countered: “I honestly don't know if I'm meeting the needs of all the kids, like, some are homeless, some are going from house to house, or some are worried about being homeless, so we do all we can, I try to do as much as I can” (M. Wildflower, Interview, June 12, 2018). This shows a *developing* level of Critical Reflection, because Mr. Wildflower is clearly reflecting on societal issues that are impediments to his students STEM learning, however he does not provide an indication that this is done with students, or within the context of the STEM classroom.

Critique of Discourse of Power. When talking about Critique of Discourse of Power, Mr. Wildflower was evenly split among the *undeveloped* and *developing* sophistication levels. Representing the undeveloped category, Mr. Wildflower repeatedly avoided answering questions regarding race and culture and gender and their role in the STEM classroom, favoring general statements like “all students are different,” “every kid is different” (M. Wildflower, Interview, June 12, 2018). While this is true, dismissal of issues of race and culture in favor of a more

colorblind or generic approach were categorized in the undeveloped category due to the non-recognition of the societal power structures that these topics represent.

It also appears that in his first two years of teaching Mr. Wildflower has had chances to reflect and opportunities to grow in this area. When asked if he thought race and culture play a role in STEM education, he responded “you know, I wouldn’t have probably told you that it did. But, we did, like, a race and racism PD in the school, and...just hearing...within *this* school...some of the thoughts and ideas that other teachers have...I was like, *man*, that’s kind of interesting, and so now I really feel like race and culture belong everywhere” (M. Wildflower, Interview, June 12, 2018). This shows a *developing* categorization of Critical Discourse of Power, as Mr. Wildflower is recognizing the societal power structure, and recognizing this within the context of STEM education, but he does not yet describe reaching the point of applying these topics to his STEM classroom instruction.

Catalysts of Mr. Wildflower’s CRE Profile. Figure 24 shows the multiple influences that Mr. Wildflower mentioned in relation to his CRE profile. Figure 25 shows that, although all of Mr. Wildflower’s multiple influences were examined for their inhibitors and catalyst status in relation to CRE, all (100%) of Mr. Wildflower’s mentions of all (100%) of these influences were determined to be *catalysts* of CRE.

Mr. Wildflower

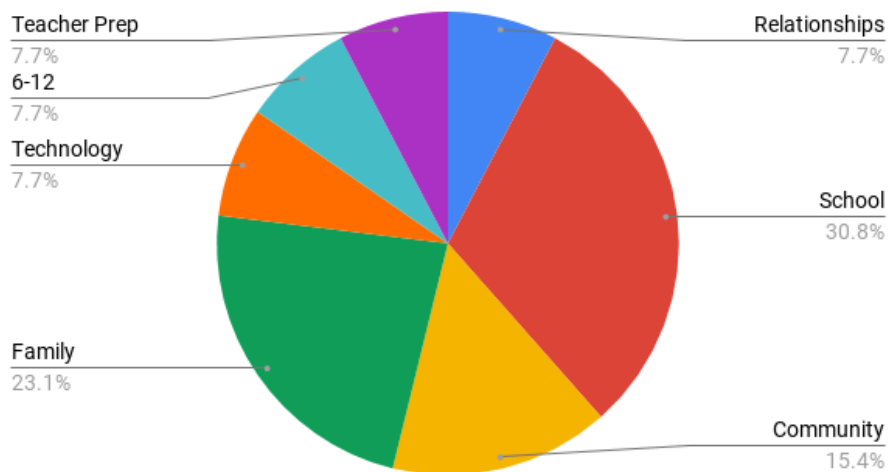


Figure 24: Influences on Mr. Wildflower's CRE Profile

Mr. Wildflower

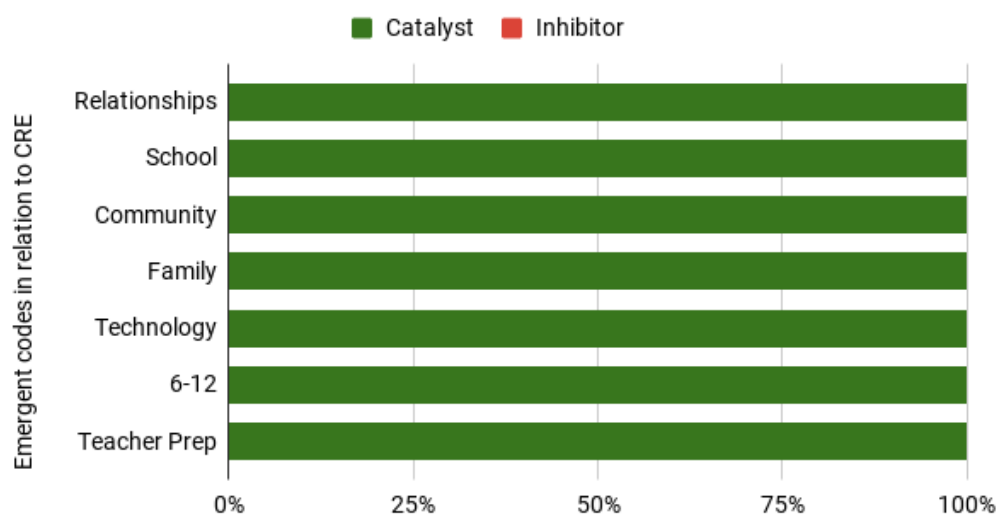


Figure 25: Mr. Wildflower's Influences on CRE, All Categorized as Catalysts

The role of relationships. When asked how he makes some of his case-by-case decisions regarding accepting late assignments or allowing a student to re-take a test, Mr. Wildflower explained “I’m a big believer, that like the first month or so, I’m just getting to know the kids. And it’s continuous, just getting to know the kids. I can have a kid that drives me insane in the classroom, but if something’s going on at home or in his neighborhood, I’m not going to hold that against him” (M. Wildflower, Interview, June 12, 2018). This comment shows how Mr. Wildflower uses his relationships with students to help make decisions to support their learning of Academic Skills and Concepts.

The role of school. Mr. Wildflower credits the diverse and sometimes challenging teaching environment for starting him along his journey towards CRE: “So, like teachers in these other schools, I don’t think they’re intentionally trying to teach science in a way that’s just not reaching these cultures, but unless you are like immersed in the culture – like we’re in the middle of it here - I just think you don’t think about it. Like I sometimes hear my kids say *I wish I could be White*, and I bet these other teachers don’t hear that because I never heard it before. That’s not something I had ever thought of” (M. Wildflower, Interview, June 12, 2018). This comment does not necessarily show a positive experience, but an experience within the context of Mr. Dogwood’s school that has encouraged or *catalyzed* his growth in relation to CRE.

The role of community. Mr. Wildflower described his relationship with the surrounding community in this manner: “I love this community and I love the people. I’ve never seen a community like this, like, once you’re in, *you’re in*. The entire community knows you, and they think highly of the school, they think highly of the academics and are also proud of the sports, and they just support what you’re doing in the classroom” (M. Wildflower, Interview, June 12, 2018). This comment shows that Mr. Wildflower conceives the surrounding community to be a

catalyst of his ability to support his students using CRE, especially Academic Skills and Concepts.

The role of family. Mr. Wildflower discusses both the role of his own family as well as the families of his students as catalysts of CRE. When asked if he noticed any predictors of academic outcomes among his students, he responded “Oh definitely. Parents. Like any student who has involved parents, I mean, nine times out of 10 they are going to be pretty pretty great students in the class” (M. Wildflower, Interview, June 12, 2018). This statement is an additional example of how Mr. Wildflower believes parents can be a *catalyst* of the Academic Skills and Concepts of students.

As seen in some previous quotes, Mr. Wildflower multiple times described the struggles of his first year of teaching. In addition to the credit that he gives to his school colleagues and his teacher preparation program, he also credits his wife with supporting him during this difficult time: “My wife, she just poured into me that “hey, you LOVE these kids.” And she just kept being consistent support saying that she through I would be awesome at this, so I kept going back and trying harder and eventually I got somewhere” (M. Wildflower, Interview, June 12, 2018). This shows another *catalyst* code for the role of family in supporting Mr. Wildflower’s ability to practice CRE.

The role of teacher education. In this comment, which also shows an additional example of the role of his school as a *catalyst*, Mr. Wildflower explains how his teacher preparation experience is also a *catalyst* of CRE in his classroom: “I was struggling the first fall, my first year of teaching. I was sinking, just sinking hard. And so I’d come in and talk with my professors, and talk with my classmates, and hearing other peoples’ stories and strategies that I could use helped me a lot. Between that and the faculty at Prairie View, I don’t know if I would

have made it without their help. And then the kids really started buying in, and I realized I was reaching these kids, and that we were building our classroom culture and developing that culture and using it in a positive way” (M. Wildflower, Interview, June 12, 2018). Mr. Wildflower’s descriptions of the support received from his teacher preparation program as an essential *catalyst* towards his classroom Cultural Competence.

Summary. Mr. Wildflower displayed *undeveloped* (40%) and *developing* (60%) categorizations of his descriptions of Academic Skills and Concepts tenet of CRE. Cultural Competence was the only tenet of CRE where Mr. Wildflower showed all sophistication levels: 7.7% *undeveloped*, 79.6% *developing*, and 15.4% *proficient*. Critical Reflection had *developing* (60%) and *proficient* (40%) codes from Mr. Wildflower, and the discussions with regard to Critique of Discourse of Power were evenly split between the *undeveloped* and *developing* categories. All of the influences that Mr. Wildflower described in relation to his ability to be a practitioner of CRE were identified as *catalysts* of CRE.

Mrs. Nimbus

To explore the fifth focus case of this research, we move outside of Green Valley County. Mrs. Nimbus teaches 10-12th grades Science at Cloudland High School in Blue Sky City Schools District. Blue Sky City Schools is located within a county adjacent to Green Valley County Schools. Blue Sky City Schools is a small, urban district that operates separately from the surrounding county school district. This district consists on only four schools, with one middle and one high school. This district employs about 130 teachers and administrators, and serves over 2,000 students. Blue Sky City Schools is well known for their STEM and technical career preparation, and partners with local businesses and industry to help ensure that the needs for the next generation of STEM and technical employees are met. This district also operates using 1:1

technology district-wide, in all grade levels and schools. This district was recognized as an exemplary school district in school year 2016-2017, which is the highest accolade available by the state governing body. Blue Sky City School’s website claims that almost 90% of their teachers have “Highly Qualified” status and/or at least a Master’s Degree. And according the state’s department of education, over 50% of this district’s teachers have an advanced education degree in addition to a Masters (EdS, EdD, or PhD), which is an unusually high percentage of advanced and terminal degrees for classroom teachers to possess in this particular region. This district has the largest per-pupil expenditures of any district represented in this research, at over \$11,500 per student per year. Blue Sky also has the highest graduation rate of any district represented in this research, at about 97%.

Blue Sky City Schools is not immune from the scrutiny regarding hiring and discipline practices with respect to racial and ethnic representations. Demographic information comparing Blue Sky City Schools’ teachers, students, and the surrounding community is presented in Table 8. Rates of discipline resulting in lost instructional time for the student is found in Table 9.

Table 8: Blue Sky City: Community, Student, and Teacher Demographics

Blue Sky City: Demographic comparisons			
Subgroup	% of total surrounding community population	% of total students population	% of total teaching population
White:	75%	65%	93%
Black:	15%	20%	5%
Hispanic/Latino:	9%	12%	2%
Asian:	1%	2%	<1%
Male:	48%	50%	39%
Female:	52%	50%	61%

Table 9: Blue Sky City Discipline by Subgroups

Blue Sky City: Student Demographics and Discipline Rates		
Subgroup	% of total student population	% of students (by subgroup) referred to OSS
White:	65%	51%
Black:	20%	41%
Hispanic/ Latino:	12%	N/A
Asian:	2%	N/A
Male:	50%	75%
Female:	50%	25%

Cloudland High School is the only high school in Blue Sky City, and is a relatively small school with a student population of around 606 students. The student demographics are about 65% White, 27% Black, and 8% Hispanic/Latino. A little over 10% of students at this school have individualized education plans, only around 1% are English language learners, and about 20% of students receive free or reduced lunch.

Cloudland High is a community school, and is known for hosting several community-outreach events including offering courses for working parents in the evenings after work hours, such a cooking courses and conversation circles for adults seeking to learn English as a second language. Additionally, Cloudland High is a high-achieving school as ranked by the state, having achieved the highest possible rank/grade from the state for the past two years. This academic achievement is recognized and celebrated by the surrounding community. Cloudland offers a public city school tuition program that draws students from several nearby public school

districts, and this program is routinely full and operates on a wait-list. Mrs. Nimbus teaches several science courses at Cloudland High: Biology 1, Chemistry 1, and Anatomy and Physiology.

Mrs. Nimbus's Survey Participation. Mrs. Nimbus indicated that the secondary school she attended was *mostly one race or ethnicity*, and that the STEM classes at this school *seldom* taught or discussed issues of race, culture, social justice, or equity. Mrs. Nimbus recalls her university experience to be *somewhat diverse*, but like her secondary experience, only *seldom* remembers issues of race, culture, social justice, and equity being taught or discussed in STEM courses. And, similar to her university experience, Mrs. Nimbus reports her current school/teaching context *be somewhat diverse*, and reports that issues of race, culture, social justice, and equity are *seldom* taught or discussed in the STEM classes she teaches. Mrs. Nimbus was selected for survey participation based on:

- 1) Given the almost uniform recollections and perceptions of her secondary experience, her university experience, and her current teaching context, Mrs. Nimbus was selected as a focus case to potentially explore factors in addition to secondary school and teacher preparation education experience.
- 2) Mrs. Nimbus teaches in a well-respected Title 1 school with a diverse student population, providing the opportunity to explore current teaching context in relation to CRE.

Mrs. Nimbus's CRE Profile. Following her participation in the interview, Mrs. Nimbus' interview data were deductively analyzed for the four categories of CRE. Figure 27 shows the frequency that Mrs. Nimbus discussed Academic Skills and Concepts, Cultural Competence, Critical Reflection, and Critique of Discourse of Power. Despite her survey response indicating

that issues of race, culture, social justice, and equity are seldom taught or discussed in the STEM classes she teaches, Figure 26 shows that most of Mrs. Nimbus's comments were categorized as *developing* or *proficient* across all tenets of CRE.

Mrs. Nimbus

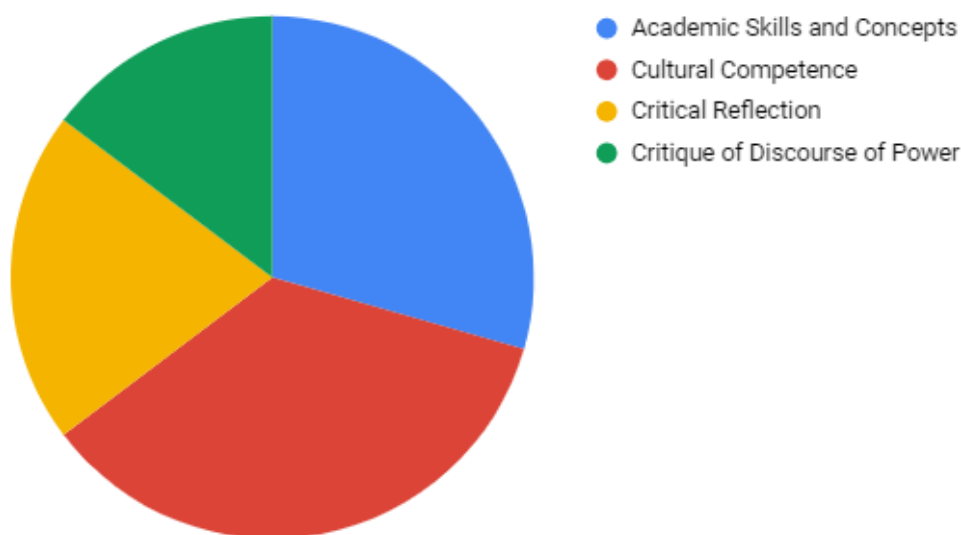


Figure 27: Mrs. Nimbus's Expressed Tenets of CRE

Mrs. Nimbus

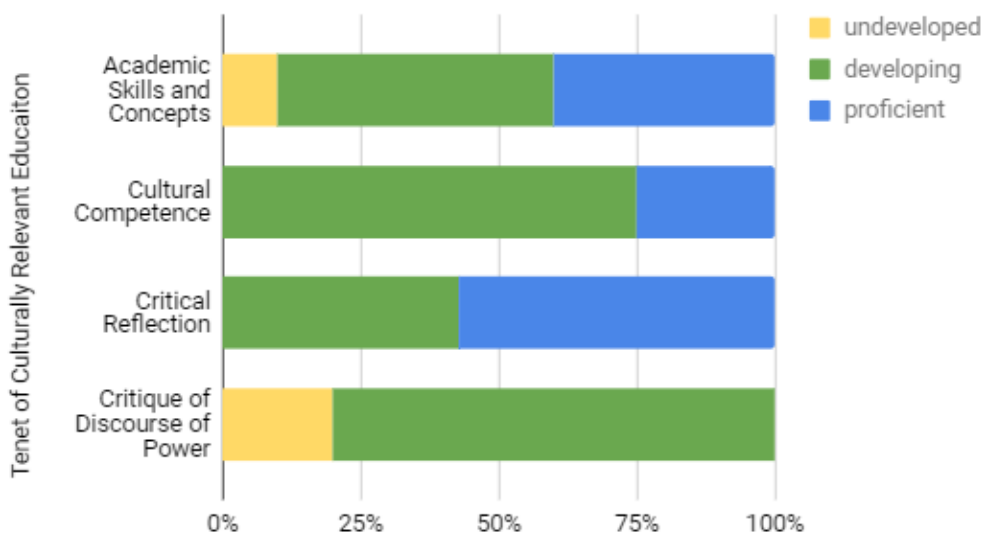


Figure 28: Mrs. Nimbus's CRE Profile

Academic Skills and Concepts. With regard to Academic Skills and Concepts, Mrs. Nimbus showed the full range of sophistication levels including *undeveloped* (10%), *developing* (50%), and *proficient* (40%). When prompted to discuss an influential moment in her teaching career, Mrs. Nimbus shared the story of a struggling student with whom she had a rocky relationship with: “She actually came and asked me for help with online chemistry, and that was the best day. That was just the best day, so we started, and I gave up my planning period, and we worked on chemistry stuff together. And she ended up graduating high school a whole year early, and I helped her” (M. Nimbus, Interview, July 20 2018). This showed a *proficient* level of Academic Skills and Concepts as Mrs. Nimbus varied her instruction to offer extra help to a struggling student, taking responsibility for that students learning and recognizing the importance of that student acquiring Academic Skills and Concepts.

When asked what she does if a student fails a test or does not turn in an assignment, Mrs. Nimbus stated like for “a student who that’s not the typical behavior for them I think it’s really important to figure out what’s going on, and if it is the typical behavior maybe I need to encourage them to make it not the typical behavior” (M. Nimbus, Interview, July 20 2018). This categorized as *developing* in the realm of Academic Skills and Concepts, as the teacher is clearly trying to support the student’s future learning and habits, but without displaying the flexibility to address the current learning situation at hand.

Cultural Competence. Mrs. Nimbus’s Cultural Competence categories were all in the *developing* to *proficient* range. She frequently mentioned that she is developing in this area in the interview, and that her school and district are starting to offer more trainings about Cultural Competence and she hopes to learn from these. At several different points in the interview Mrs. Nimbus talked about the importance of foundational knowledge, and how she struggles to teach

both foundational content knowledge while fitting in aspects of CRE. When asked about why she indicated on the survey that she rarely teaches or discusses issues of race, culture, social justice, or equity in her STEM classroom, Mrs. Nimbus responded: “we typically tend to focus on the content aspect of this and building that foundational knowledge, we do a little bit with ethics, not really social justice issues, but the ethics of genetic engineering, stuff like that. I think the standards are more restrictive than I would like them to be. If we had more time we could go into more depth and you could take it in the social justice direction and that would be amazing but we are restricted by time” (M. Nimbus, Interview, July 20 2018). Although Mrs. Nimbus focuses on the importance of foundational knowledge, she also qualified this with the recognition that not all standards she is required to teach qualify as the foundational knowledge essential to progress in science education or career pathways. When discussing time pressure in covering all state required standards, Mrs. Nimbus observed: “I mean, if I don’t get to teach my kids about Biuret and Benedict’s solutions, honestly, I think they would be okay. I think that time would be much better spent going into the cultural and historical aspects of our content” (M. Nimbus, Interview, July 20 2018). These comments show a *developing* sophistication level in relation to Cultural Competency because Mrs. Nimbus is recognizing cultural aspects as important in STEM education, but indicates that she struggles to incorporate them into her classroom instruction.

Critical Reflections. Mrs. Nimbus’s CRE Profile in relation to Critical Reflections showed 49.2% *developing* and 57.1% *proficient* categorizations. Mrs. Nimbus was very forthcoming in the interview about her own Critical Reflections on racial matters at her school and within her district. As previously mentioned, her school district has recently been in the news for issues regarding both hiring practices and the disproportionately White teaching faculty, as well as the overrepresentation of students of color in the discipline records of the

district. Resulting, Mrs. Nimbus alluded to these issues and how these issues have impacted how she reflects upon her teaching practice several times during the interview in a very open and honest manner. For example, when asked if she noticed predictors of academic success with her students, she responded

“I have noticed, and maybe this is speaking poorly of me, but I have noticed myself...um...being curious about certain students. Like honestly, if they are Black or ESL or something, I’ll sometimes wonder if what I’m throwing at them is too much, not really based on their skin but maybe based on how they speak or something like that, I’ll make an assumption that they can’t do this. And I’ve learned that that most of the time they’ll meet my expectations and sometimes blow the other students away. And I realize that maybe speaks poorly about me, and it’s possibly the result of me growing up in a not very diverse situation, you know, my biases, but I’ve learned to put that aside and make sure I’m giving everyone the opportunity to learn” (M. Nimbus, Interview, July 20 2018).

This shows a *developing* level of Critical Reflection, as Mrs. Nimbus is examining her own life experiences and how they impact implicit bias, but there is no mention of integrating this type of process into classroom STEM teaching and learning.

When asked if she addresses scientific topics in her classroom that are also political, Mrs. Nimbus responded “Oh yes, I think it’s important to talk about the importance of making informed decisions about things, and I encourage them to make their own decisions, but at the same time a student will come to you and say “I just read THIS” and then I have to say “okay, well where did you read that” and we talk about who wrote it and why they wrote it, and just understanding that people who are putting information out there sometimes have an agenda behind it, and one of our standards is recognizing bias in science so we talk about what bias

might be present in what they are reading, and if it really is even science” (M. Nimbus, Interview, July 20 2018). This description of a classroom interaction qualifies as a *proficient* categorization of Critical Reflection as Mrs. Nimbus provides an example of critically examining a topic directly related to scientific understanding collaboratively with students in her classroom.

Critique of Discourse of Power. Critique of Discourse of Power was the only tenet of CRE that Mrs. Nimbus did not show *proficiency* levels of sophistication, only *undeveloped* (20%) and *developing* (80%). When asked if these issues of inequity and power should have a place in the STEM classroom, her response was “I mean, I think it’s important to acknowledge that these issues have been there in the past, and are maybe, kind of, still there? And maybe this is me putting on rose colored glasses or whatever, maybe I’m being very naive about it. But I think it’s good to acknowledge that this is the way things have been in the past, but that we have moved away from that now” (M. Nimbus, Interview, July 20 2018). This demonstrates an *undeveloped* categorization as Mrs. Nimbus, although considering her position, is not acknowledging societal power structures in this comment.

When asked if she notices any differences in motivation or achievement based on race or gender. Mrs. Nimbus stated “not really, but now I do notice that our classes are grouped by levels and there are demographic patterns that exist in those grouped, leveled classes. My inclusion classes, which are typically more ELL and Black students. So although I don’t see a difference in ability by race, clearly someone does, because these students are all grouped together in the inclusion class” (M. Nimbus, Interview, July 20 2018). Here, Mrs. Nimbus is critiquing a common occurrence when grouping students that is a function of societal power structures. But, as Mrs. Nimbus did not discuss addressing any issues of power with students, this qualified as a *developing* sophistication level.

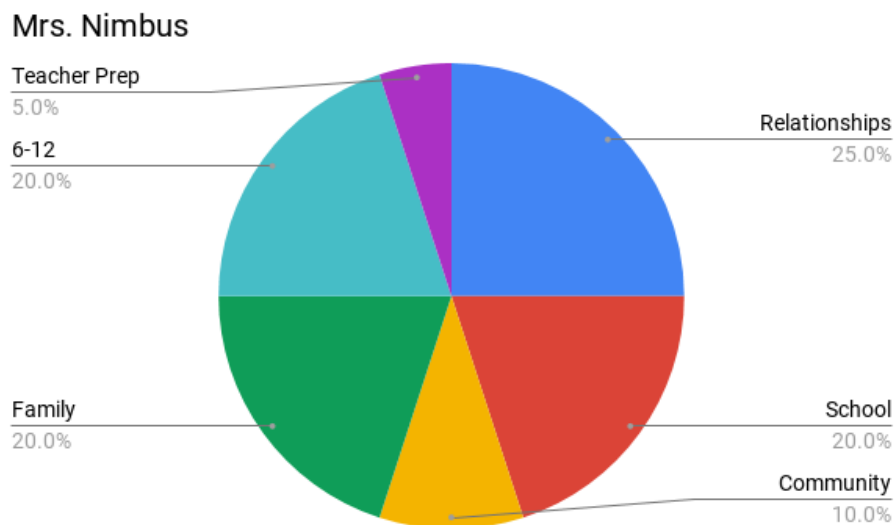


Figure 26: Mrs. Nimbus's Influences on CRE

Catalysts and Inhibitors of Mrs. Nimbus's CRE Profile. Mrs. Nimbus mentioned the roles of relationships, school, community, family, her own secondary education, and teacher preparation as influences to her CRE profile. All of her comments involving these themes were further categorized as catalysts or inhibitors of CRE, as presented in Figure 29.

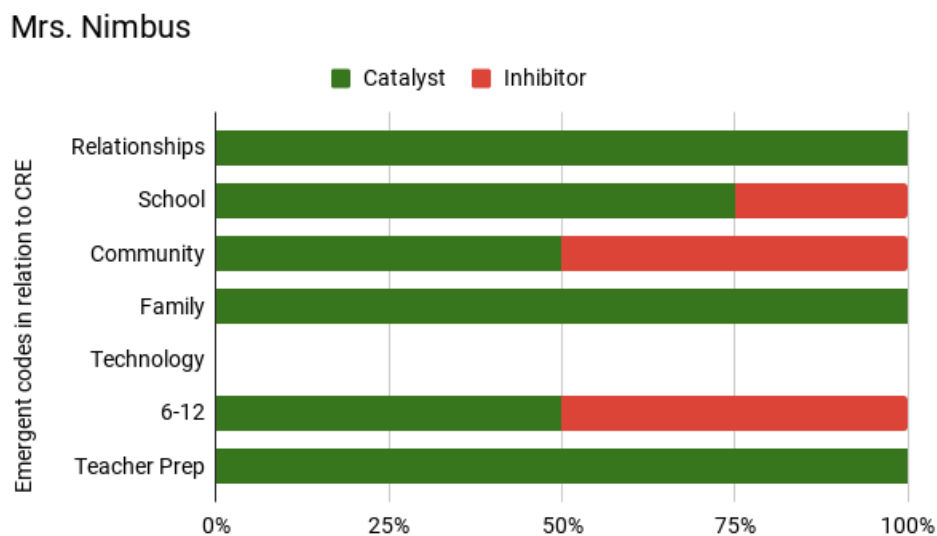


Figure 27: Mrs. Nimbus's Influences Regarding CRE Categorized as Catalysts or Inhibitors

The role of relationships and the role of school. Like other interview participants, Mrs. Nimbus highlighted the role of building relationships with students as a 100% *catalyst* towards CRE. As Mrs. Nimbus expressed that building relationships was an express focus from her school administration, the role of relationships and the role of the school as a catalyst of CRE are discussed here together. In a discussion that started when she was how the surrounding community thinks of her school, Mrs. Nimbus responded ‘I’ve worked for a few different school districts here, and this is the first one that I have worked for that has said focus on relationships with your kids. The others were all about data data data, testing testing testing, data data data. We might spend 5 minutes talking about data, but then we move on and talk about how we can build relationships with our kids and build those connections to the community. That’s just the culture of our district, to put our students and our place in the community first’ (M. Nimbus, Interview, July 20 2018). This was classified as a *catalyst* of CRE as Mrs. Nimbus indicated the focus on relationships supreme to the focus on data and testing is a beneficial teaching and learning environment.

The role of community. Mrs. Nimbus mentioned to role of the community as both a *catalyst* and an *inhibitor* of CRE. When asked if the community thinks highly about the school, she mentioned: “well, there have been some incidents, and I can’t really talk specifics, but some issues that have been in the news and gone to the school board, and I think it’s really put a rift between some of the cultures in our community and the school” but also that “most people in the community are proud of the school and supportive of the school” (M. Nimbus, Interview, July 20 2018). This discussion shows both *catalyst* and *inhibitor* categories in relation to the role of the surrounding community.

The role of family. Mrs. Nimbus mentioned family as a *catalyst* (100%) of CRE, specifically in relation to Academic Skills and Concepts. When asked if she notices any predictors of academic outcomes among her students, Mrs. Nimbus stated: “the biggest thing I have seen is parent involvement, if parents can be involved, that’s just huge most of the time” When asked what other stakeholders should take responsibility for academic outcomes, Mrs. Nimbus similarly responded “if the parents can get involved and be supportive, that is really, really big” (M. Nimbus, Interview, July 20 2018). These comments show how Mrs. Nimbus perceives the role of family to be a catalyst towards the academic success of her students.

The role of secondary education. Mrs. Nimbus recalls her own secondary learning experience as both a *catalyst* (50%) and an *inhibitor* (50%). In her survey, Mrs. Nimbus remembered her own secondary learning experience as *mostly one race or ethnicity*. When asked about this experience, like other interview participants Mrs. Nimbus mentioned that way she was taught in high school is not applicable to her current teaching context. In further recollections of her secondary school experience, she elaborated: “there were some incidents that happened in middle and high school. A family moved in that was of a different race, and they had a cross burned in their yard, and it was terrifying. And I realized there was something wrong with a lack of diversity. So I grew up in a situation without a lot of diversity, and I saw that wasn’t really a good thing, so I feel like that made my pay attention and even seek out teaching in a diverse setting” (M. Nimbus, Interview, July 20 2018). This anecdote exemplifies how negative experiences can be catalysts of CRE.

The role of teacher preparation. Mrs. Nimbus entered teaching through an alternative licensure program, which did not require the attendance of a teacher preparation program for prospective teachers in hard-to-staff, high needs subject areas. So, when Mrs. Nimbus entered

teaching, she did not have a traditional teacher education experience to rely on in relation to implementation of CRE, or anything else, in her classroom. In the years that have followed her entering the teaching profession, she has returned to school and is working towards an advanced degree in education. Only 5% of her comments regarding the influences on her CRE profile mentioned teacher education, and these mentioned her current teacher education program as a *catalyst* of CRE, it is important to realize that the timeline of her teacher preparation is different than other focus cases.

Summary. Mrs. Nimbus's CRE profile showed *undeveloped*, *developing*, and *proficient* categorizations for Academic Skills and Concepts. For both Cultural Competence and Critical Reflection, only *developing* (75%, 49.2%) and *proficient* (25%, 57.1%) sophistication levels were communicated. For Critique of Discourse of Power only *undeveloped* (20%) and *developing* (80%) categorizations were identified. Mrs. Nimbus communicated that the role of relationships and the role of family were 100% *catalysts* of her ability to enact tenets of CRE in her STEM classroom. The majority (75%) of her discussions about the role of school also reported that influence to be a *catalyst*. The role of community and the role of her own secondary school were evenly split between being a *catalyst* and an *inhibitor*, according to the analysis of Mrs. Nimbus's descriptions. Mrs. Nimbus did not have a teacher education experience until after she had been teaching for a few years, but did report this experience to be a *catalyst* of her ability to be a practitioner of CRE.

Mrs. Trout

The final focus case for this study is Mrs. Trout. Mrs. Trout teaches Algebra 1 and math recovery credit at the High School level at Waterfall Online School. Waterfall Online School is a part of the Rocky River County school district, but draws students from many areas of the state.

Rocky River County is a small, rural district that consists of less than a dozen traditional, brick-and-mortar schools and one online school. Rocky River County employs about 275 teachers and administrators, and serves close to 3500 students. The average per-pupil expenditure in this district is the lowest of all three districts represented in this study, at slightly over \$8500 per year. Rocky River also has the lowest graduation rate of any district represented in this research; in between 75% and 80%.

Table 10: Rocky River County: Community, Student, and Teacher Demographics

Rocky River County: Teacher, Student and surrounding community demographic representations			
Subgroup	% of total surrounding community population	% of total students population	% of total teaching population
White:	98%	92%	98%
Black:	<1%	5%	1%
Hispanic/Latino:	1%	3%	0%
Asian:	<1%	0%	0%
Male:	50%	50%	22%
Female:	50%	50%	78%

Unlike the Green Valley County and Blue Sky City, the racial/ethnic distributions of Rocky River teachers closely represent that of the surrounding community: all are over 98% White. For comparison purposes, this demographic information is presented in Table 10. One note on these data is the effect on the online school on the student racial demographics. Multiple brick-and-mortar schools in this district are 100% White; only two brick-and-mortar schools in Rocky River County have Black student (or students) enrolled. The appearance of diversity in

student enrollment in this district is largely due to the diverse enrollment in the online school. Relevant student discipline data was unavailable for this district, as online schools deal with discipline in a much different manner than brick-and-mortar schools, and given the low numbers students in any subgroup for this district.

Waterfall offers elementary, middle, and high school courses, and with 733 students, it is the largest school in Rocky River County. Waterfall student demographics are as follows: 70% White, 20% Black, 6% Hispanic/Latino, and 4% Asian. Almost 20% of the students enrolled at Waterfall qualify for free or reduced lunch, and almost 15% of Waterfall students have an individual education plan.

Waterfall was established five years ago and quickly received thousands of applicants for their online-only school platform. After several years of struggles implementing effective online education, Waterfall was under close scrutiny from the State Department of Education and decided to change both enrollment procedures and online course delivery methods. When applying to attend Waterfall, parents/guardians must now sign an agreement that states that students will have access to the technology needed to conduct school online, and also a parent/guardian must contractually agree to act as an academic coach for the student, taking responsibility for making sure a student attends class online and completes assignments in a timely manner. Possibly in reaction to Waterfall's lackluster academic performance, or the new contractual admissions requirements, enrollment in waterfall declined by 150% over the past three years.

In order to address the lack of evidence of academic achievement, Waterfall also began conducting online classes in a synchronous delivery method, requiring students and teacher to sign into a learning management platform at the same time to conduct virtual classes. Previously,

instruction and assignments for the unit were all sent as a complete package to students, who were supposed to work through these units at their own pace and return the completed units to the teacher for grading within a specified window of time. The change to synchronous online course delivery has increased academic achievement measures somewhat (as quantified by mandated state standardized testing). However, Waterfall remains with the lowest overall school ranking given by the state department of education.

Mrs. Trout has taught with Waterfall for the past three years, where she teaches Algebra 1 and math recovery credit for high school students who have math courses that they must pass in order to meet graduation requirements. Although she is currently licensed to teach Algebra, she was not licensed in this subject area when she began teaching Algebra for Waterfall three years ago. Teaching was not Mrs. Trout's first career: she entered teaching through an alternative pathway that allowed her to teach special education at a high needs school while pursuing teacher licensure. Thus she began her teaching career as a special education teacher in a brick-and-mortar middle school, and then taught high school math at a private religious school before accepting a job with Waterfall. She added her Middle Grades and Algebra licensure after deciding to teach at Waterfall; she attended a one-week state-approved training to achieve the Algebra 1 teaching certification.

Mrs. Trout's Survey Participation. Mrs. Trout's survey responses can be found in Appendix J. In her survey participation, Mrs. Trout identified that her own secondary school education was *somewhat* diverse, she *strongly disagreed* that teachers and principals seemed to value diversity, and she indicated that she *never* remembered issues of race, culture, social justice, or equity being taught or discussed in STEM classes. When asked about her current teaching context/school. She *strongly disagreed* that students learn about how race and ethnicity

can play a role in who is successful, and also *strongly disagreed* that her school provides opportunities to learn about social justice. She *strongly agreed* that race and culture play a role in STEM education, however, indicated that issues of race, culture, social justice, and equity are *never* taught or discussed in the STEM courses she teaches. Mrs. Trout was selected as an interview participant for this research due to the following:

- 1) To provide the unique perspective of an educator with experience teaching in both brick and mortar schools as well as teaching for an online school, and
- 2) To investigate the appearance of disconnect between Mrs. Trout *strongly agreeing* that race and culture play a role in STEM education, but indicating that students in the classes she teaches *never* have the opportunity to discuss these issues.

Mrs. Trout's CRE Profile. Figure 30 shows that Mrs. Trout discussed issues of Cultural Competence more than any other tenet of CRE during her interview, with 54% of her comments relating to Cultural Competence. Possibly due to her unique school context, Mrs. Trout struggled to answer questions in relation to Critical Reflection (8% of comments) and Critique of Discourse of Power (15%), so limited comments were available on these tenets for further analysis.

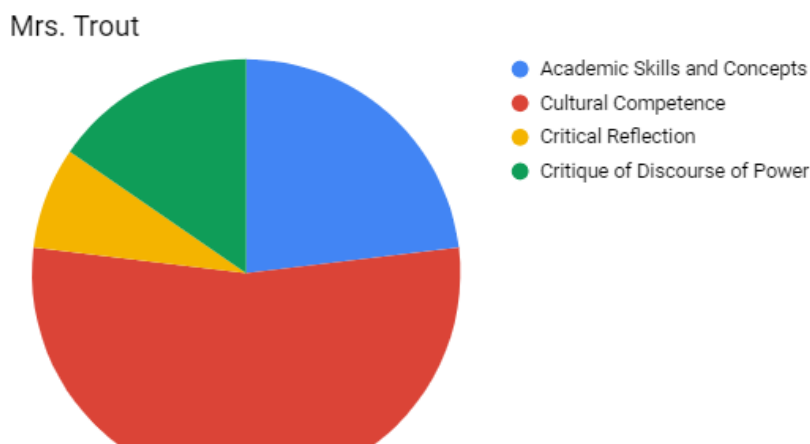


Figure 28: Mrs. Trout's Expressed Tenets of CRE

Figure 31 shows the categorization of Mrs. Trout's interview data into *undeveloped*, *developing*, and *proficient* categories. These sophistication levels are explained below in the unique context of an online educational delivery school.

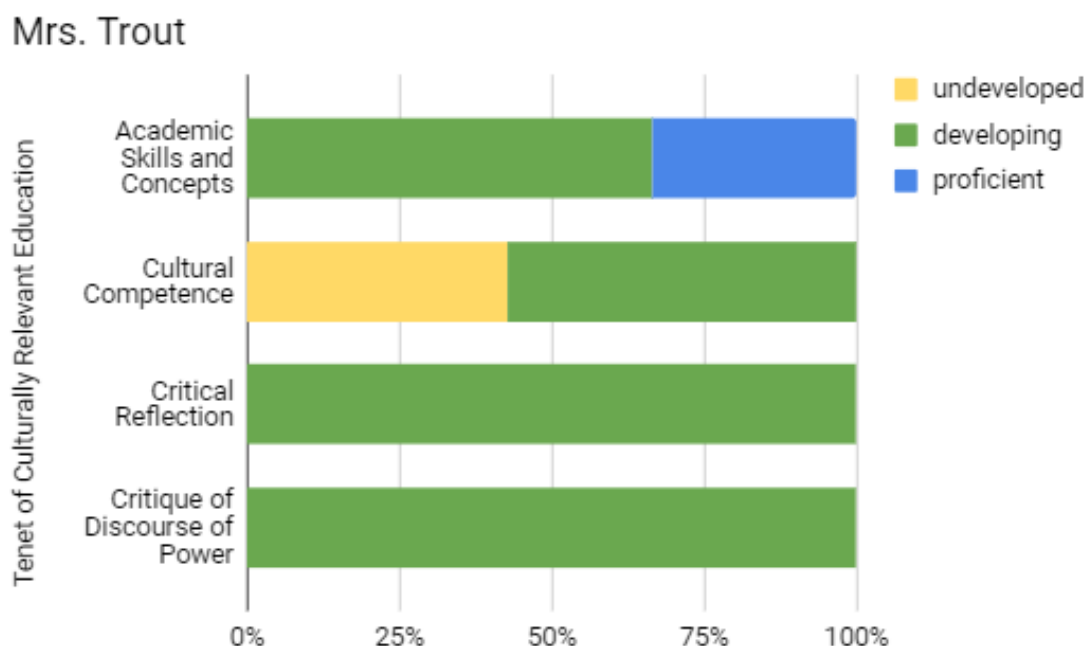


Figure 29: Mrs. Trout's Proficiencies in Relation to the Tenets of CRE

Academic Skills and Concepts. Mrs. Trout's comments regarding academic skills and concepts were categorized as *developing* (67%) or *proficient* (33%). Mrs. Trout spoke to the academic supports that are provided by her school in making sure that students are achieving mastery of necessary skills and concepts. She explained that she does not have much control over a grading system, as Waterfall assigns grades largely as pass/fail, where students must pass an end-of-course examination to receive credit for the class. When asked what happens in her classroom when a student fails a test or does not turn in an assignment, she explained "first and foremost, I would direct message the student which automatically sends an email to the parent, and say, 'hey, I'm going to need to retake the test, or ask I've noticed that you haven't taken this

test do you need help, check out this Khan academy video, if you need help let me know.” (M. Trout, Interview, June 12, 2018). This description of classroom practice shows a *developing* level of Academic Skills and Concepts, as Mrs. Trout is taking some responsibility for student academic growth, but it appears there is little ability to allow for flexibility and/or variations in instruction to support students academically. Mrs. Trout talked about making sure that students are completing modules in time, and passing formative assessments, and being proactive about communicating with parents when students first show signs of falling behind.

When asked how her instruction prepares students to be critical thinkers and communicators, she responded: “I think, by encouraging them to know that they can make mistakes and that by continuing to try they will get there. That even if they don’t get it the first time we can keep working on it until they do. I teach a lot of the growth mindset . . . I do this thing at the end of the year where I ask them what's the most valuable thing you learned this year, I had one say that learning to make mistakes and that it will be OK” (M. Trout, Interview, June 12, 2018). This comment represents a *proficient* sophistication level of Academic Skills and Concepts, as Mrs. Trout describes assuming responsibility for student learning and also the flexibility needed to make sure that acquisition of skills and concepts occurs.

Cultural Competence. In her interview, Mrs. Trout spoke the most about the cultural competence aspect of CRE, and these comments were categorized into the *undeveloped* (43%) and *developing* categories (57%). When considering her comments on Cultural Competence, it is important to take the online school platform into consideration, which Mrs. Trout describes as follows: “Students are taught just like you would in a classroom, you can use a PowerPoint or show videos or upload anything you want to put up there, and kids have a chat microphone and webcam ability, and you have a microphone and a webcam, but they all turn off their webcams.

So you are actually teaching class online in real time. If the kids don't show up they are marked absent" (M. Trout, Interview, June 12, 2018). When asked if she notices any predictors of her students' achievement, she stated "it's hard to say because you don't see them" (M. Trout, Interview, June 12, 2018). When asked if she notices a difference in achievement based on gender or race she said "that's one of the things that's really unique about the virtual academy because I don't really know my kids races, unless they turn on their cameras" (M. Trout, Interview, June 12, 2018). When asked if the teachers and principals of her school value diversity, she responded "that's a hard question in this environment because it's just not, you know, out there" (M. Trout, Interview, June 12, 2018). These comments regarding Cultural Competence were classified as *undeveloped* as, virtual school or not, they did not show an understanding that culture has a bearing on the school environment.

When asked if she can design and enact lessons that incorporate cultural or societal issues that students face at home or in their communities, Mrs. Trout responded "I can to a point. Our community is statewide, so things that are big like wildfires or storms that come across the state. Or I use [reference to popular theme park in the Southeast region that has a multinational, cultural celebration yearly]. Everyone knows about [the theme park's multinational cultural celebration]" (M. Trout, Interview, June 12, 2018). This reference showed an example of Mrs. Trout struggling to incorporate culture into her classroom STEM instruction, and was thus categorized as *developing*.

Critical Reflection and Critique of Discourse of Power. Mrs. Trout's limited comments about Critical Reflection and critique of discourses of power yielded 100% *developing* categories, as she recognized larger, societal issues and expressed interest in incorporating these issues and teaching strategies into her classes, but cited the online format of her school as an

impediment to actualizing these aspects of pedagogy. When asked if issues of equity and power have a role in math classrooms, she responded “absolutely, our kids need to see that it isn’t always White males who made the discoveries, they are just credited with them, there were women, there were people of Color. Math people don’t come from one mold; no one is just born a math person. And if you say you’re bad at math, you’re not bad at math. You’re just not trained” (M. Trout, Interview, June 12, 2018). This represents a *developing* representation of Critical Reflection and Critique of Discourse of Power as the teacher is recognizing the role of societal constructs in relation to mathematics and recognizes their place in math instruction, but does not explain how she engages in these critiques with her students as a part of her classroom practice.

Mrs. Trout

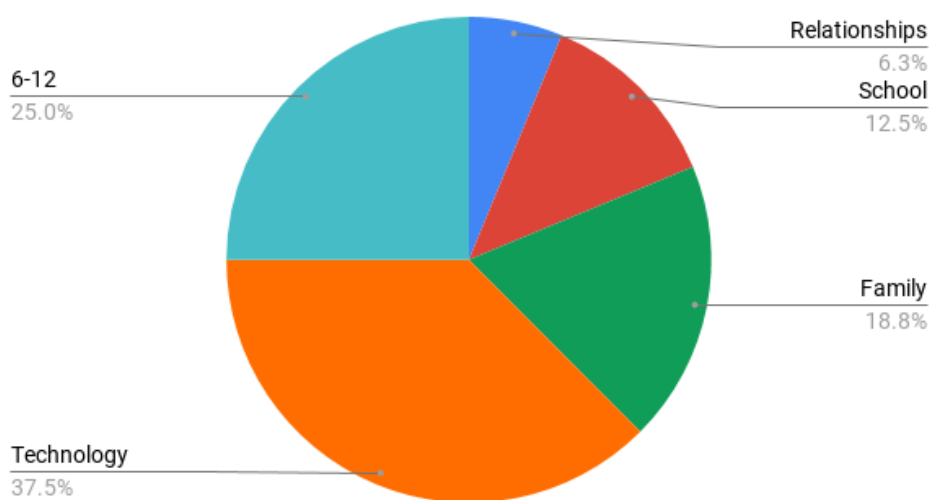


Figure 30: Mrs. Trout's Influences in Relation to CRE

Mrs. Trout

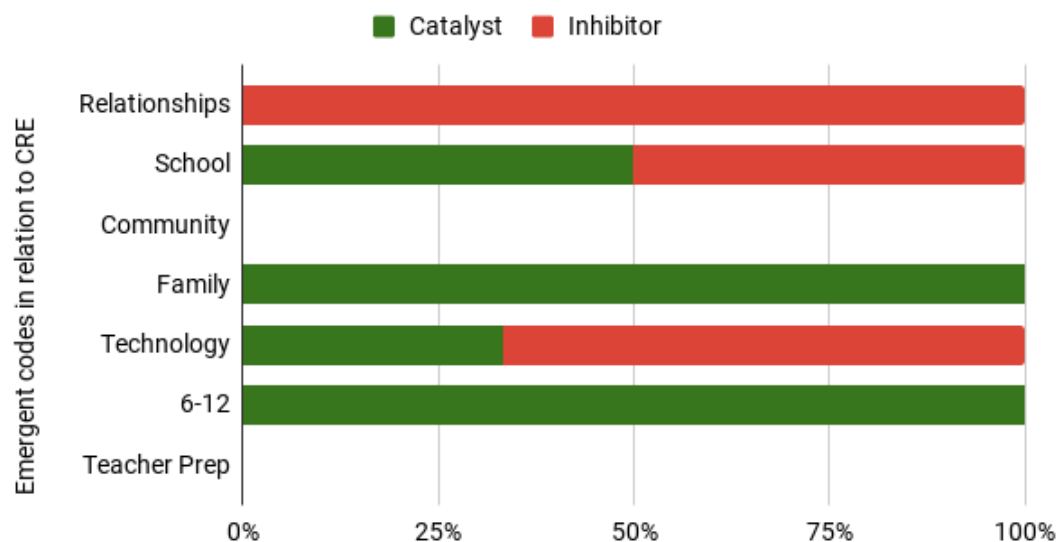


Figure 31: Mrs. Trout's Influences Categorized as Catalysts or Inhibitors

Catalysts and Inhibitors of Mrs. Trout's CRE Profile. Mrs. Trout described the role of relationships, school, family, technology, and her own secondary education as influences in relation to her ability to be a culturally relevant STEM educator. She has no mentions of community influence, perhaps given the context that an online school draws from multiple communities. Additionally, mentions of her teacher preparation program are absent, as she did not attend a teacher education program (instead achieving provisional licensure and then attending state-approved licensure program). The distributions of Mrs. Trout's influences on CRE found in Figure 32, and the categorizations of these influences as *catalysts* or *inhibitors* of CRE is presented in Figure 33.

The role of relationships Mrs. Trout indicated that the role of student relationships can be an *inhibitor* of CRE. When discussing her relationships with students she repeated sentiments that came up elsewhere in the interview; that not being able to see her students inhibits her

ability to enact CRE. When asked how her knowledge of students backgrounds influences her teaching, she stated “you don’t see the kids, you don’t know their race or ethnicity or family traditions, so how do you implement that in an environment where you don’t know what you are dealing with? You get to have conversations with them on chat or the microphone before class, so you kind of get to know them, but it’s only in an online way” (M. Trout, Interview, June 12, 2018). This comment speaks to the role of the school as well, but also shows that Mrs. Trout believes the relationships she is able to have with students do not support her ability to be culturally competent in her role as an online STEM educator.

The role of the school. Mrs. Trout mentioned that her current school context is both a *catalyst* and an *inhibitor* of CRE. One unique aspect of an online school that Mrs. Trout described as a *catalyst* of CRE was that she reports the online school “has actually become kind of like a safe haven for kids who are normally bullied in school, like children who are gay or transgender or overweight or kids who have medical issues” (M. Trout, Interview, June 12, 2018). This comment was a *catalyst* of CRE as it shows the potential for her school to provide options for vulnerable students who would benefit from culturally relevant instruction.

Mrs. Trout also described her school as an *inhibitor* of CRE in her instructional practice. When asked why students in her classes do not discuss issues of race, culture, social justice, or equity even though she indicated on her survey that she strongly believes these play a role in STEM education, she indicated that her school context has a lot to do with this disconnect. “It’s partially the online format, I mean, if I don’t know their race and culture how am I supposed to use that in my teaching? It’s partially because we are forced to put a year’s worth of learning into $\frac{3}{4}$ of the school year so there’s no room, you have to get all your standards in before the EOC, so you don’t have time for anything” (M. Trout, Interview, June 12, 2018). This shows how she

believes the school, and educational requirements like standardized tests, stand in the way of her ability to be a culturally relevant educator.

The role of family. Mrs. Trout spoke about the role of family as a 100% catalyst of her instructional use of CRE. When asked if she notices predictors of academic outcomes in her class, she mentioned “an active learning coach makes all the difference. When students sign up [for the virtual school] there is a person who says they will be their learning coach, who will make sure they get online and do their work and go to class. Most of the time that’s the parent, and having a parent who is involved makes all the difference” (M. Trout, Interview, June 12, 2018). This shows that Mrs. Trout believes that parent willing to partner with the teacher as a learning coach involvement is a *catalyst* of the student’s academic outcomes.

The role of technology. In a probably direct relationship to her teaching in an online school, the majority of her influences in relation to CRE referred to technology. And, as seen in Figure 43, most of these technology codes were identified as *inhibitors* to implementation of CRE. Mrs. Trout repeatedly mentioned that teaching and learning online was not compatible with, or inclusive of, aspects of CRE other than Academic Skills and Concepts. These conversations about technology overlapped with comments about the tenets of CRE and the other influences on her ability to enact CRE, as with an online school, the presence of technology emerged in response to every interview prompt. Examples of technology being a catalyst of CRE was Mrs. Trout’s observation that an online school can become a “safe haven” for students often bullied or otherwise marginalized in more traditional schools. An example that Mrs. Trout identified of technology being an inhibitor of CRE include the lack of sense of community or community resources to draw on, given that the school is statewide. Additionally, as previously quoted, Mrs. Trout repeatedly mentioned the inhibiting aspect of not being able to see her

students. These comments were also *inhibitors* of CRE given Mrs. Trout's perception that she could not integrate race or culture into her classroom instruction because she was not aware of the races and cultures of her students.

The role of secondary education. All of Mrs. Trout's comments about her secondary education experience were identified as catalysts of CRE. However, all of these comments centered on Mrs. Trout's negative experiences in high school that have motivated her towards different practices. When asked to describe her secondary education experience, Mrs. Trout said "There are a lot of teachers who just should not be teaching. You know what I mean?" (M. Trout, Interview, June 12, 2018). In her survey participation, Mrs. Trout indicated that her secondary education experience was *somewhat diverse*, and when asked if this experience influenced her current teaching style, she responded "yes, but not in the traditional way. I think I felt like it wasn't done right, so I wanted it to be done differently" (M. Trout, Interview, June 12, 2018). This comment shows how a negative experience at the secondary level in relation to diversity is a *catalyst* to Mrs. Trout's inclinations towards CRE.

The role of community and the role of teacher preparation. Mrs. Trout also did not mention community in relation to CRE. Again, as with many of her codes and categories, this could be in relation to the online format of her school, making community impact and involvement less obvious or overt. Additionally, absent was Mrs. Trout's mentions of teacher preparation as related to her teaching practices. This is most likely a function of her entering teaching as a career-changer in a high-needs subject area (Special Education), who did not attend a teacher preparation program as a pathway to obtaining teacher licensure.

Summary. Mrs. Trout's CRE profile shows 100% *developing* categorizations for Critique of Discourse of Power and Critical Reflection, although in her interview was often

struggled to speak to these tenets of CRE. Her sophistication levels for Academic Skills and Concepts showed both *developing* (67%) and *proficient* (33%) categorizations, while her Cultural Competence showed *undeveloped* (43%) and *developing* (57%) categorizations. Of the multiple influences on her CRE profile discussed by Mrs. Trout, she mentioned the role of the relationships she is able to build *inhibits* her ability to enact CRE in the school. The role of technology in relation to CRE was also largely (67%) *inhibitory*. She identified qualities of her school that both *catalyze* (50%) and *inhibit* (50%) her ability to enact CRE, and she identified the roles of family and her own secondary school experience largely as catalysts of her ability to be a practitioner of culturally relevant STEM education.

Cross-Case Analysis

Following the analysis of the interview data, the data for each individual focus case participants were compared across all cases to identify cross-case findings.

Survey Data Cross-Case Analysis

Figure 34 shows all interview participants perceptions of race, culture, and social justice, as reported during their survey participation. This series of questions asked participants to rank their recollections of the inclusion of race, culture, and social justice in the STEM classes they took in secondary education, the STEM or STEM teaching methods courses they took at the post-secondary level, as well as in the STEM classes they currently teach. The scale used for these questions was 1(*never*) through 5 (*frequently*). As seen in Figure 34, a wide range of perceptions on this topic is represented among these research participants. All research participants reported that issues of race were taught or discussed in their secondary STEM classes *never* or *rarely*. Mrs. Dogwood and Mr. Wildflower both *frequently* remembered issues of race and culture in their STEM courses at the college/university level. Mr. Wildflower indicated

that issues of race are *often* taught or discussed in the STEM classes he teaches. Mr. Redbud, Mrs. Dogwood, Mrs. Clover, and Mrs. Nimbus all indicated that issues of race are taught or discussed *sometimes* in their STEM classes, and Mrs. Trout indicated that issues of race are *never* taught or discussed in her STEM class.

When asked about cultural inclusion in the STEM class, Mr. Wildflower and Mrs. Clover both indicated that they *often* discuss or teach issues of culture in their STEM classes. Mr. Redbud, Mrs. Dogwood, and Mrs. Nimbus report they teach or discuss issues of culture *sometimes*, and Mrs. Trout's survey showed her response to this question to be *never*.

When prompted to quantify their inclusion of issues of social justice or equity in the STEM classroom, Mrs. Trout indicated that her students *never* talk about these issues in her STEM Class. The remaining focus case participants indicated that their students talk about social justice and equity *sometimes* in their STEM classes.

Survey Findings Figure 34 does not show clear patterns, indicators, or predictors of CRE enactment in the classroom. These survey responses do show that all research participants remember issues of race or culture were seldom taught in the STEM classes they took at the secondary level. Additionally, the majority of positive responses to the questions about race, culture, and social justice inclusion in STEM courses came at the college/university level, where two out of six participants responded *frequently* and only one participant responded *never*. However, this was not a predictor of inclusion of these issues in their own classrooms. Additionally, when compared to the CRE profiles of each individual participant, we do not see a clear correlation between the experiences identified in the survey and the levels of sophistication regarding each tenet of CRE constructed from an analysis of the interview data. This is not an

Perceptions of Race, Culture, and Social Justice in STEM Education						
Survey Question / Participant	Mr. Redbud	Mrs. Dogwood	Mr. Wildflower	Mrs. Clover	Mrs. Nimbus	Mrs. Trout
Do you remember issues of race being taught or discussed in a secondary STEM class?	1	1	2	1	2	1
Do you remember issues of race being taught or discussed in a college/university STEM class?	3	5	5	2	2	2
Are issues of race being taught or discussed in the STEM class(es) you teach?	3	3	4	3	3	1
Do you remember issues of culture being taught or discussed in a secondary STEM class?	1	1	2	2	2	1
Do you remember issues of culture being taught or discussed in a college/university STEM class?	3	5	5	2	2	1
Are issues of culture being taught or discussed in the STEM class(es) you teach?	3	3	4	4	3	1
Do you remember talking about social justice or equity in a secondary STEM class?	4	1	1	2	2	1
Do you remember talking about social justice or equity in a college/university STEM class?	3	4	5	2	2	2
Do you or your students talk about social justice or equity in the STEM class(es) you teach?	3	3	3	3	3	1

Figure 32: Interview Participants' Perceptions of Race, Culture, and Social Justice in STEM Education.

unexpected result, as the design of this research recognizes survey data collection as insufficient to comprehensively investigate the research question, and thus relies on interview data as well.

Interview Data Cross-Case Analysis

The distribution of the tenets of CRE expressed by all six interview participants are found in Figure 35. 39% of all categorized interview data identified across all six interviews referred to the Cultural Competence tenet of CRE. Categorization for Critical Reflection and Critique of Discourse of Power were equally represented at 21%, while 19% of categorizations referred to Academic Skills and Concepts.

All Interview Participants

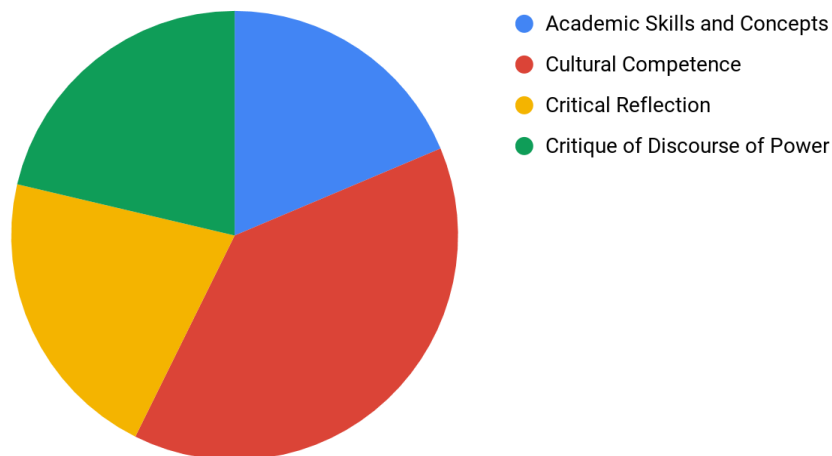


Figure 33: Focus Cases Expressed Tenets of CRE

Each interview participants' evidences were first categorized by tenet of CRE, and then further was categorized into an *undeveloped*, *developing*, or *proficient* representation of the tenet of CRE, as delineated by the rubric found in Table 4. Across all cases, these levels of sophistication are presented in two ways (Figures 36 and 37):

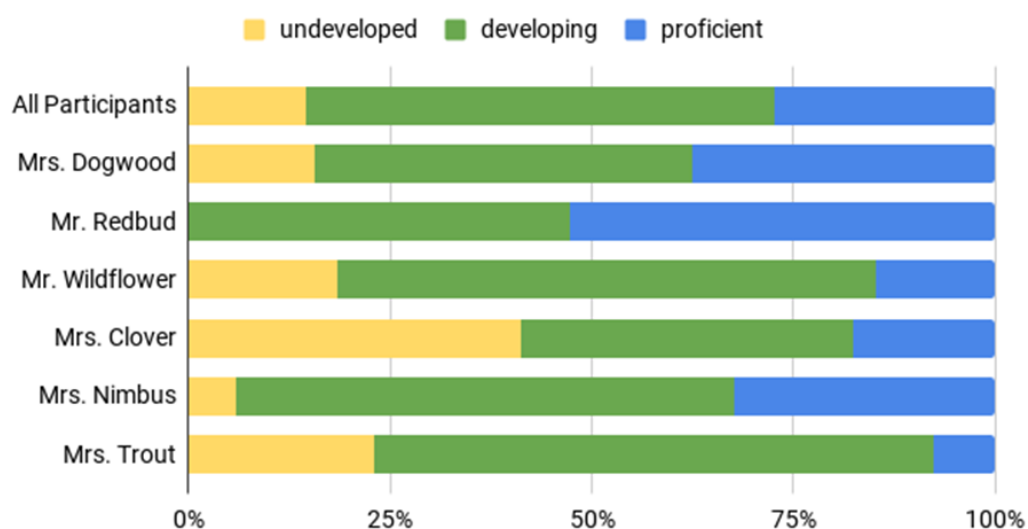


Figure 34: Focus Cases Combined Proficiencies in Relation to the Tenets of CRE

- 1) The *undeveloped*, *developing*, and *proficient* levels of sophistication, disaggregated by focus case participant and but aggregated across all tenets of CRE for each participant, is found in Figure 36, and
- 2) The *undeveloped*, *developing*, and *proficient* levels of sophistication, disaggregated by tenet of CRE aggregated for all focus case participants, is represented in Figure 37.

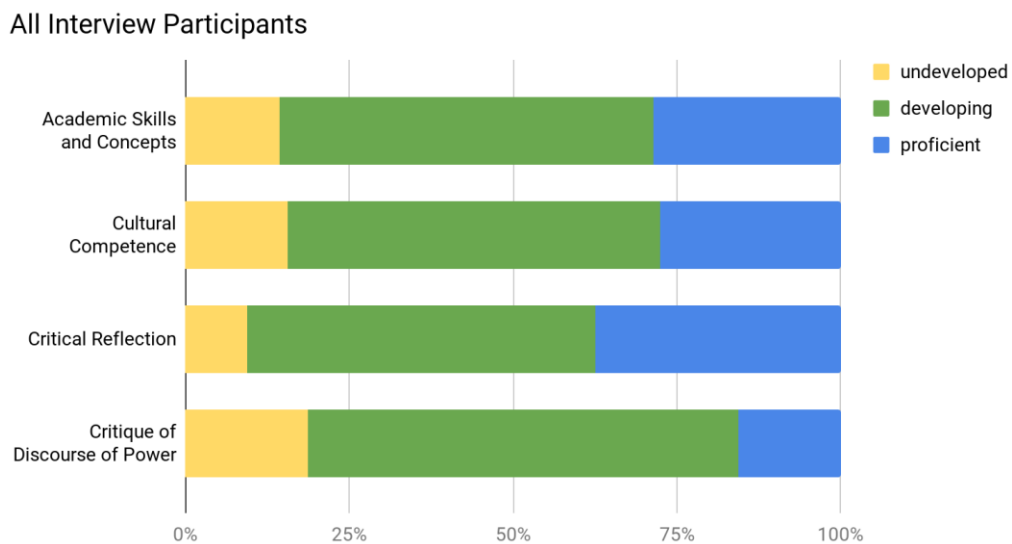


Figure 35: All Participants CRE Sophistication Levels

Undeveloped Categories. Figure 37 shows that Critique of Discourses of Power presents as the tenet of CRE with the most *undeveloped* categorizations, with 20% categorized as *undeveloped*. When examining solely the *undeveloped* categorizations of all focus group participants (Figure 36), we see that five out of six research participants showed *undeveloped* categorizations in relation to CRE. Additionally, *undeveloped* categories are the minority of categories across all cases, accounting for only 14.7% of the total categorizations. All participants who showed *undeveloped* categorizations also showed both *developing* and

proficient categories. Even the participant with the largest percentage of *undeveloped* categories (Mrs. Clover, with 41.2 percent *undeveloped*) also showed an equal percentage of developing categorizations, plus 17.6% in the proficient category. This is a promising result in a critical case analysis, conducted with the underlying assumption and understanding that despite literature and learning theory regarding CRE as effective pedagogy, STEM teachers struggle to actualize CRE in the classroom.

Developed Categories. Across all interview participants and all tenets of CRE, the majority level of sophistication *developing*. Academic Skills and Concepts and Cultural Competence both display 57% *developing* categorizations. The Critical Reflection realm shows 53% developing categorizations, and Critique of Discourse of power displays 66% *developing* categorizations. Critical Reflection showed the largest percentage of *proficient* categorization, with 37.5% of all Critical Reflection mentions belonging to the *proficient* category. *Developing* categories are the majority across all cases, with 58% of deductively coded comments involving the four tenets of CRE belonging to the *developing* category. This finding remains largely true for individual participants as well, as five out of six participants displayed *developing* categorizations as their single-largest representation of categories. All participants who displayed *developing* categories also displayed *proficient* categories.

Proficient Categories. 27.3% of all participants' categorizations in relation to the tenets of CRE were *proficient*. Additionally, Figure 36 shows that all interview participants had comments and conceptions of CRE that were categorized as *proficient*. All participants also showed a majority of combined *developing* and *proficient* categories. Mr. Redbud is the only participant to show a narrow majority of *proficient* categorizations. Five out of the six

participants with *proficient* categorizations also showed both *developing* and *undeveloped* categorizations.

The examination of the *undeveloped*, *developing*, and *proficient* sophistication levels of all focus group participants across all tenets of CRE leads to the following finding that will be discussed further in Chapter 5:

Finding 1: Being a practitioner of CRE is a continuum, not a binary.

Survey and Interview Data Cross-Case Analysis

Comparing survey data, presented in Table, with the spectrum of sophistication levels for focus case participants, presented in Figure 46, provides additional findings regarding the learning pathways in relation to CRE. Three questions on the survey ask directly about the focus case participant's conception of how they practice, or do not practice, culturally relevant STEM education in their classrooms:

1. Are issues of race being taught or discussed in the STEM class(es) you teach?
2. Are issues of culture being taught or discussed in the STEM class(es) you teach?
3. Do you or your students talk about social justice or equity in the STEM class(es) you teach?

Comparing each interview participants' responses on these three questions with their CRE profile, showing their levels of sophistication across each tenet of CRE (Figure 46), shows little predictive correlation. Mr. Wildflower indicated on his survey that issues of race and culture are *often* taught or discussed in the STEM classes he teaches, however, his CRE profile shows the full spectrum of *undeveloped*, *developing*, and *proficient* categories. Mr. Wildflower actually shows the second lowest percentage of *proficient* categorizations of his overall conceptions of CRE, at 14.8 %. Mr. Dogwood's survey results purported that he only *sometimes* addresses

issues of race, culture, social justice, or equity in the STEM classes he teaches, but his CRE profile shows the highest level of sophistication of the focus case participants as the only participant with no *undeveloped* categorizations and the highest percentage of *proficient* categorizations (52.8 %) across all tenets of CRE. Considering the survey responses and their lack of predictive correlation with these focus case participants' CRE profiles leads to an additional finding of this research:

Finding 2: Teachers can display proficiency in tenets of CRE even if they do not self-report or self-identify as a practitioner of CRE

Figures 38-40 show the multiple influences in relation to focus case participants' CRE profiles. Figure 38 shows the aggregated multiple influences on focus group participants' CRE profiles. The role of school is identified as the most frequent (29.6%) influence on CRE across all focus cases, while the role of teacher education (6.4%) is identified the least, among all identified influences of CRE.

All Interview Participants

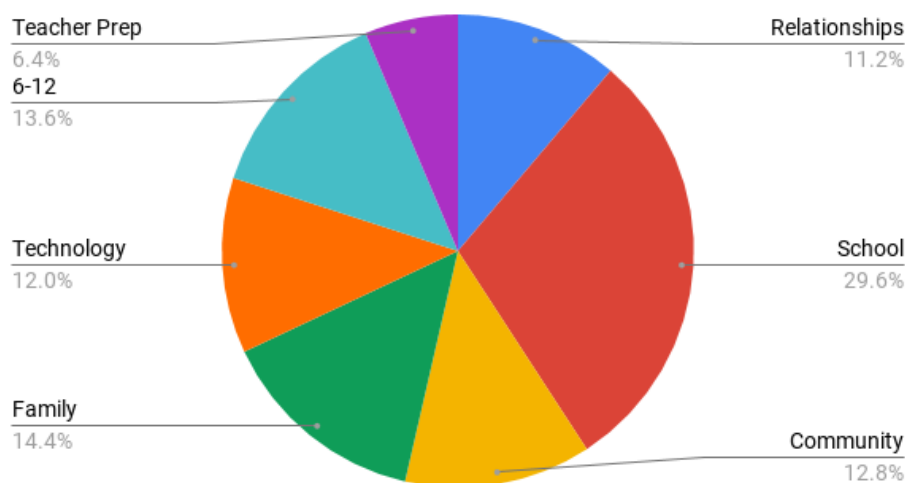


Figure 36: Influences on All Focus Cases CRE Profiles

Each of the multiple identified influences on CRE was additionally categorized as a *catalyst* or an *inhibitor* of CRE. Figure 39 shows the percentages of the *catalyst* and *inhibitor* categories found across all cases, for each individual influence on CRE.

All Interview Participants

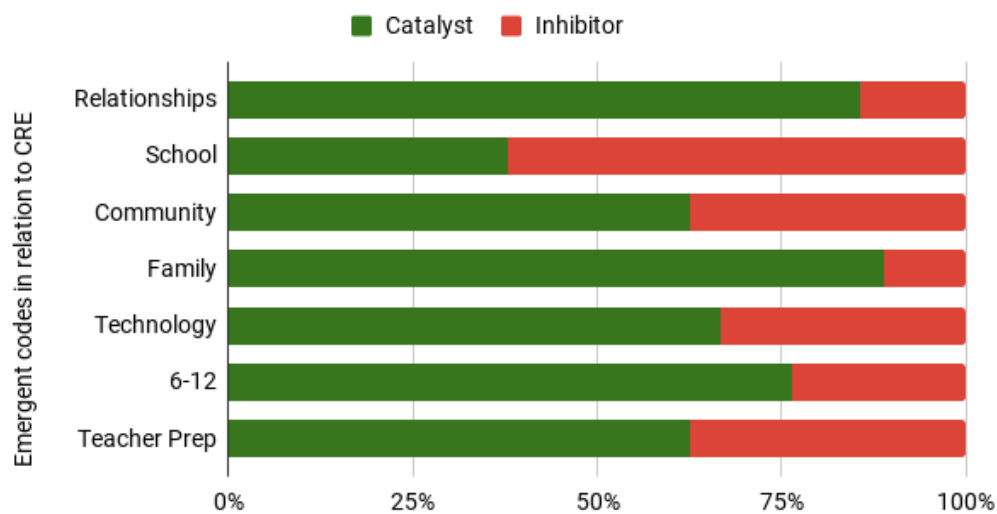


Figure 37: Catalysts and Inhibitors of All Focus Cases Combined

All Interview Participants' Emergent CRE Categories

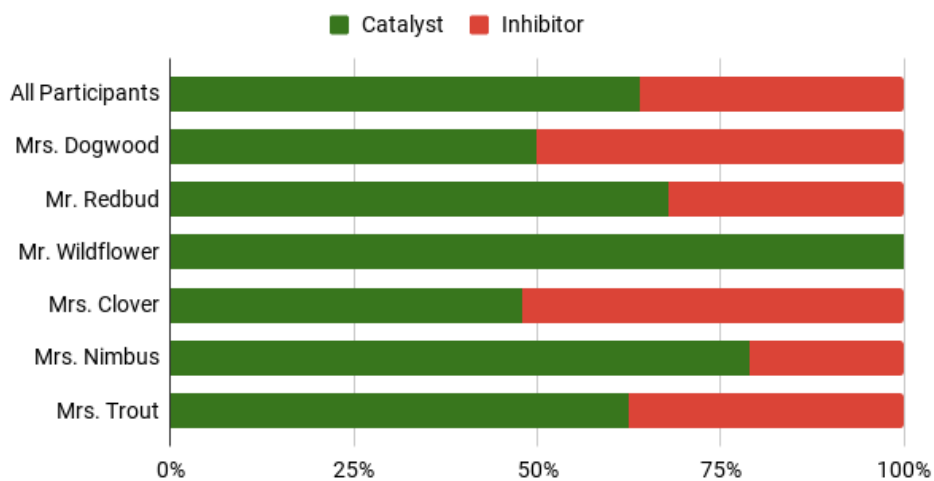


Figure 38: Catalyst and Inhibitor Totals for Each Interview Participant

As is seen from Figure 39, all of the multiple influences identified across all focus cases have the ability to be both an *inhibitor* and a *catalyst* of CRE. Most of the influences on CRE were largely identified to be a *catalyst* of CRE. The role of relationships and the role of family codes contain the largest percentage of *catalyst* categorizations when considering the group of interviews as a whole. Only one influence on CRE was identified, when combining the data of all interview participants, to consist of a majority of *inhibitor* status in relation to a teacher's ability to implement CRE: the role of the school. Out of all the identified influences of CRE, the role of the school accounted for the largest (29.6%) theme identified as an influence of CRE by the interview participants (Figure 39). And, Figure 39 shows that across all focus cases, the role of the school was the only influence with a majority *inhibitor* role (63 %) in relation to CRE. Given the perception among this group of research participants that the role of the school is a major and *inhibitory* influence in relation to their ability to practice culturally relevant STEM education, the role of the school will be further discussed and examined in the context of educational realities in Chapter 5.

Figure 40 shows a comparison of all interview participants' combined multiple influences regarding CRE, and their categorizations as *catalysts* or *inhibitors* of CRE. *Catalyst* categories were identified if the code was mentioned as a benefit, help, or support in relation to CRE. *Inhibitor* category refers to codes that are obstacles or impediments in relation to CRE. It is important to note here that not all codes categorized as *catalysts* were positive experiences; many interview participants identified negative experiences as pivotal to their motivations toward CRE.

Catalyst Categories. Mr. Wildflower was the only participant to display 100% *catalyst* codes. Five out of six interview participants showed a majority of *catalyst* categories, meaning

that most discussed experiences that promoted and encouraged their use of CRE more frequently than they discussed matters that detracted from their ability to actualize CRE.

Inhibitor Categories. All participants, except for Mr. Wildflower, displayed *inhibitor* categories in relation to at least one of the emergent codes in relation to CRE. For most participants, *inhibitor* categories were outnumbered by *catalyst* categories. Mrs. Clover is the only interview participant to display a slim majority of *inhibitor* codes (52%). An additional finding for Mrs. Clover is that she displayed the largest percentage of any participant of *undeveloped* CRE categorizations, at 41.2% (Figure 36). However, Mrs. Dogwood, who has a comparable percentage of *inhibitor* codes to Mrs. Clover, displayed the second-largest percentage of *proficiency* categories across all cases. Thus, the correlation between the occurrences of *catalyst* and *inhibitor* categories do not correlate to the distributions seen among research participants for *undeveloped*, *developing*, or *proficiency* in relation to CRE. Given the roles of *inhibitor* categories with almost all research participants, it is a finding of this research that both *catalyst* and *inhibitor* categorizations of the influencing factors of CRE are a part of the learning progressions of STEM teachers in relation to enacting CRE in their classrooms.

This cross-case analysis of the multiple influences, both *catalysts* and *inhibitors*, in relation to all participants' CRE profiles, leads to an additional research finding:

Finding 3: The data collected in this research identified several specific influences and experiences that shape educators in relation to becoming a practitioner or non-practitioner of CRE.

In Chapter 5, three of the multiple influences (and the role of technology, the role of teacher education, and the role of school) identified by this research and data analysis will be discussed and explored in the context of 21st century educational realities. These three specific influences

in relation to the CRE sophistication levels of focus case participants were selected for additional analysis as a result of this cross-case analysis.

The role of technology. Constructing a diverse focus case of interview participants led to multiple perspectives on the role of technology in relation to CRE. Mrs. Dogwood and Mr. Redbud both teach in a 1:1 technology environment, and their conceptions on the role of technology was mostly that of a *catalyst* in relation to their ability to practice CRE: Mrs. Dogwood's technology mentions were categorized as 75% *catalysts*, while Mr. Redbud's technology mentions were 100% *catalysts* in relation to CRE. However, not all focus-case teachers in technology-rich environments agreed with the conceptions of Mrs. Dogwood and Mr. Redbud. Mrs. Trout, who teaches at an online school, viewed the technology needed to operate math education via an online platform dominantly as an inhibitor (67%) of her ability to be a culturally relevant STEM practitioner. This disconnect between the conceptions of the role of technology in schools that have made explicit commitments to operate in a technology-rich environment warrant further examination in Chapter 5 regarding the role of technology's impact on teacher's abilities to enact CRE.

The role of teacher education. The review and analysis of relevant literature conducted prior to engaging in this research led to the identification of the role of teacher education as critical and pivotal in the learning progressions of teachers in relation to CRE. Additionally, the survey instrument used in this research to recruit and select diverse cases for focus group participants made the assumption, through asking a series of questions related to each participants' teacher education experience, that the teacher education process indeed played some role in this pathway towards or away from culturally relevant STEM education. However, the outcomes of this research do not show teacher education as a dominant influence in relation to

CRE; as only 6.4% of all comments from all interview participants about influences in relation to CRE referenced their teacher preparation programs, even though interview questions specifically and explicitly asked about each participant's teacher education experience. As the survey asked about perceptions of the teacher education experience and not about logistics of the teacher education experience, these details emerged during the interviews when focus case participants were asked questions about their teacher preparation.

When comparing all focus cases represented in this research we see a broad representation of pathways towards becoming a teacher, and not all of these pathways involved a STEM teacher education experience. Mr. Redbud, Mrs. Clover, and Mrs. Dogwood are the only three teachers who participated in traditional teacher preparation programs, where they completed significant education coursework as well as clinical, supervised teaching experiences before entering the classroom as the teaching professional responsible for guiding student growth and learning. Mrs. Dogwood completed a Bachelor's degree in mathematics, and then a Master's degree in mathematics education. Her Master's degree included significant coursework and supervised clinical experiences that all occurred prior to her obtaining her own classroom as teacher of record. Mrs. Dogwood is the only teacher represented in this research who participated in a traditional teacher preparation program in a STEM field.

While Mr. Redbud and Mrs. Clover also completed traditional teacher preparation programs, neither one of them completed such programs in a STEM field. Both completed elementary education teacher preparation programs. Mr. Redbud has since completed additional training and certifications necessary to teach secondary mathematics. Mrs. Clover has not perused additional science or science pedagogy training or coursework, nor training/coursework

specific to the demands of secondary grades education, although she expressed the desire to do so.

Mrs. Nimbus, Mr. Wildflower, and Mrs. Trout entered teaching through the nebulous and multiple definitions of alternative teacher preparation pathways. Mrs. Nimbus completed a Bachelor's and a Master's in a Biological Sciences field, without any science education or pedagogy coursework, and entered the classroom as a certified teacher who was closely supervised her first few years by a partnership with a local University with the aim to increase the supply of high-demand STEM teaching positions. Although she has completed significant additional training in education since this time, at the point she entered the classroom, she had no formal education training or coursework participation, and no supervised clinical learning experiences.

Mr. Wildflower obtained a BS in Biology, after which he enrolled in an alternative teacher preparation program that allows him to enter the teaching profession and earn his Master's in education simultaneously. He is currently in his second year of this program, and anticipates completing his coursework and requirements for his Master's within the next calendar year. At the time he entered his classroom as teacher of record, however, he, like Mrs. Nimbus, had no education training or coursework participation, and no supervised clinical learning experiences.

Mrs. Trout received a Bachelor's in Business Administration and worked as an accountant for several years before deciding to peruse teaching. She began her teaching career in the area of special education, with a program similar to Mrs. Nimbus's, which allowed non-certified teachers to enter the classroom in high-demand teaching positions without completing any formal education training. She achieved her special education certification through this

program, but now she teaches math. Until this year, she was not certified to teach mathematics; this year she completed a one-week state sponsored course to achieve an Algebra 1 certification.

This analysis of the pathways towards teaching among focus case participants echoes national trends. Chapter 5 will further discuss the role of teacher education in preparing culturally relevant STEM educators, given the 21st century reality that STEM teachers, as well as teachers in high-needs schools, increasingly enter the classroom without partaking in a teacher education program.

The role of school. Figure 38 shows that the role of the school was the influence discussed most frequently (29.6%) in relation to implementing CRE across all focus case participants. Additionally, Figure 48 shows that across all of the multiple influences of CRE identified by this research, the role of the school displays the largest percentage (63 %) of *inhibitor* categories when gating the data of all focus case participants. For these reasons, the role of the school will be discussed further in Chapter 5.

Summary of Findings

Cross-case analysis of survey responses showed that our research participants have diverse recollections of the inclusion of race, culture, and social justice in the STEM classes they took, both at the secondary and post-secondary level, as well as in the STEM courses they currently teach. According to the survey responses, the recollections of previous STEM coursework experiences did not serve as a universal or generalizable predictor of the teacher's enactment of aspects of CRE in their current STEM classrooms.

Analysis of each participant's context for teaching shows that the research participants teach in diverse and varied settings. A caveat on this research results was introduced, in that two of the three districts represented have been publically grappling with issues of race and culture,

and have resultantly taken steps to address these issues. The evaluation of these issues and the attempts to address these issues is beyond the scope of this research, however, I simply recognize that conducting this research in this context may have impacted the survey and interview data that this research is based upon.

Findings of the cross-case analysis show that most (five out of six) research participants showed the full variety of sophistication levels, *undeveloped*, *developing*, and *proficient*, in relation to the tenets of CRE. In addition, all focus case participants showed multiple influences in relation to their CRE sophistication levels, and most participants (5 out of 6) displayed both *inhibitor* and *catalyst* categories in relation to the identified multiple factors that influence a teacher's ability to enact CRE in the STEM classroom.

Thus, a summary of the findings, across all cases and data collected and analyzed for this research, that will be further discussed in chapter 5 are as follows:

Finding 1: Being a practitioner of CRE is a continuum, not a binary,

Finding 2: Teachers can display proficiency in tenets of CRE even if they do not self-report as a practitioner of CRE,

Finding 3: The data collected in this research identified several specific influences and experiences that shape educators in relation to becoming a practitioner or non-practitioner of CRE. These multiple influences need to be discussed, explored, and researched in the context of 21st century educational realities.

Chapter 5: Discussion, Implications, and Recommendations.

The documented racial participation gaps in STEM higher education and STEM careers (Chen & Soldner, 2013; NAS, 2011; Vest, 2011), the recognized important role of secondary STEM teachers in motivating students to enter and persist in STEM careers (Amador & Soule, 2015; Choi & Chang, 2011; Knezek, Christensen, & Tyler-Wood, 2015; Lee & Shute, 2010), combined with the reality that the STEM teaching force is predominantly White (USDE, 2016) provides the foundational purpose for this research. This project's underlying, research-based assumption is that culturally relevant STEM education is a way to address the above concerns; however, secondary STEM teachers struggle to implement CRE in their classrooms (Adams & Laughter, 2012; Fasching-Varner & Seriki, 2012; Laughter & Adams, 2012; Nam, Roehrig, Kern, & Reynolds, 2013; Ukpokodu, 2011). In order for CRE to become a reality in our STEM classrooms, we first need to understand why and how some teachers become practitioners of CRE while some do not.

In search for answers to this question, this study looked to describe the multiple influences on teachers' pathways towards becoming, or not becoming a practitioner of CRE. The central research question addressed is:

What are the major influences and experiences that shape an educator into a practitioner or non-practitioner of culturally relevant STEM teaching? The analysis of multiple sources of data collected with the goal of responding to the research question led to the following findings, which are discussed individually:

Finding 1: Being a practitioner of CRE is a continuum, not a binary.

Finding 2: Teachers can display proficiency in tenets of CRE even if they do not self-report as a practitioner of CRE.

Finding 3: The data collected in this research identified several specific influences and experiences that shape educators in relation to becoming a practitioner or non-practitioner of CRE. Specific influences that need to be discussed, explored, and researched in the context of 21st century educational realities are the role of technology, the role of teacher education, and the role of the school.

Finding 1: Being a Practitioner of CRE is a Continuum, Not a Binary

The first finding of this research is that being a practitioner of culturally relevant STEM education is a continuum, not a binary. In this research, interview data was categorized according to the four tenets of CRE: Academic Skills and Concepts, Cultural Competence, Critical Reflection, and Critique of Discourse of Power. These categorizations were then additionally identified as *undeveloped*, *developing*, or *proficient* sophistication levels in regards to the teachers' conception of actualizing each tenet in the STEM classroom. The results of this analysis showed that all focus case participants showed multiple levels of sophistication in relation to culturally relevant STEM education; additionally, all but one focus case participant showed the full spectrum of *undeveloped*, *developing*, and *proficient* sophistication levels in relation to CRE.

Finding 1 of this research speaks to one of the purposes of this study, which recognized that existing research on CRE in STEM often centers on describing the process, procedure, or impact of a single intervention. This study acknowledged an underlying assumption that there is no one experience that shapes the attitudes and dispositions of a teacher, but instead that multiple influences over time impact the values and priorities that a STEM teacher chooses to bring into their classroom instruction. By design, this study describes multiple influences and themes, occurring over long spans of time, that influenced teachers' in relation to the enactment of

culturally relevant STEM education. The finding that CRE actualization is a continuum, not a binary, supports the idea that the impact of a single CRE intervention is limited in the ability to move an educator completely into the *proficient* realm of all tenets of CRE. In order for short term interventions to be effective, they would have to be tailored to each participant's current conception and existing sophistication levels of CRE, and current descriptions of CRE professional development do not describe acknowledging the need for differentiation based on a current CRE profile in supporting CRE development. This finding speaks to an implication for further research: future research into supporting enactment of CRE into STEM classrooms should be respective that teachers can display a continuum of understandings of CRE and thus might need targeted, long-term supports in areas of most need (*undeveloped* categorizations).

Finding 2: Teachers Can Display Proficiency in Tenets of CRE Even If They Do Not Self-Report as a Practitioner of CRE

The second finding of this research is that teachers can display proficiency in tenets of CRE even if they do not self-report as a practitioner of CRE. The results of this research showed that teachers who did not indicate strong motivations towards or practitioner levels of CRE on their survey still showed proficiencies in multiple tenets of CRE following the analysis of interview data.

Finding 2 of this research supports an additional identified significance of this study; which was that current research in culturally relevant education focuses largely on educators with a pre-existing interest or inclination towards implementing aspects of cultural relevance in their classrooms (Byrd, 2016, 2017, 2018). This focus is defensible, given that sample of culturally relevant educators would be needed to investigate culturally relevant practices in the classroom. This study sought to fill a research void and took different approach, however, not limiting

participation to solely those who show an inclination towards, or claim to be practitioners of, the tenets of culturally relevant STEM education. The finding that teachers can display proficiencies regarding CRE without self-reporting inclinations toward or proficiencies with CRE justifies this research scope and design, and allows for the following implication for further research: In order to continue investigating the learning pathways of teachers in relation to culturally relevant STEM education, the multiple influences in relation to all teachers' conceptions and enactment of CRE should be included (not just those with a predisposition towards culturally relevant STEM education).

Finding 3: Specific Influences on CRE

The data collected in this research identified specific influences and experiences that shape educators in relation to becoming a practitioner or non-practitioner of CRE. The multiple influences identified by this study were the role of relationships, the role of school, the role of community, the role of family, the role of technology, the role of secondary educational experience, and the role of teacher preparation. Three of the influences identified by this research (the role of technology, and the role of teacher education, and the role of school) are further discussed here in the context of 21st century educational realities.

The Role of Technology

The role of technology emerged as a common theme that most of the six focus case participants mentioned in their interview with respect to their ability to implement culturally relevant STEM education. The role of technology was selected for additional examination based on the findings that participants' views about technology's impact on CRE actualization were split between the conception that technology is a *catalyst* and an *inhibitor* of CRE. The recommendations put forth here are designed to promote the *catalyst* potential of technology in

relation to CRE while minimizing the *inhibitive* aspects of technology in relation to CRE. The review and analysis of current STEM CRE literature conducted prior to conducting this research did not identify technology specifically as a major factor influencing implementation of CRE in the classroom. This could be due to the recent proliferation of technology-rich environments in urban or diverse schools; alternatively, this lack of the role of technology represented in the foundational research could be an indication of a missed opportunity. Given the lack of representation of the role of technology in the literature reviewed prior to conducting this research, a brief examination of literature published while this study was being conducted will be used to contextualize the findings of this study in relation to the role of technology in catalyzing or inhibiting CRE.

Keir and Khalil (2018) investigated the use of 1:1 technology to engage students in real-world math and science problem solving which also incorporated principals of engineering. Their discussion firmly support the ideas shared by multiple interview participants that 1:1 technology use can *catalyze* the use of CRE in the STEM classroom. Keir and Khalil (2018) state that by using 1:1 technology “teachers, students, and committed professionals can access a myriad of representational materials that can shift the dominant narrative of STEM from white ethnocentrism to one that is more grounded in students’ experiences and funds of knowledge” (p. 106). Keir and Khalil (2018) additionally assert that “digital technologies have semiotic potential of being a mediator between social justice and STEM, as current events, opinion editorials, persuasive essays and other curricular resources can support teachers in contextualizing student tasks and showing how STEM can be used to advocate for injustice in urban communities” (p. 106). Keir and Khalil’s (2018) discussions closely echo those of Mrs. Dogwood and Mr. Wildflower, the research participants in this study who also taught in schools

with 1:1 technology, who identified their use of technology as a catalyst of CRE by allowing the introduction of multiple resources into their classrooms, and allowing them to tailor instruction to students' diverse backgrounds.

In investigating STEM-rich digital makerspaces and the long-term impact they have on students participating in these activities, Tan and Barton (2018) similarly found that the role of technology can catalyze the use of culturally relevant STEM education towards supporting academic outcomes for students, but also that caveats do exist. Tan and Barton (2018) recognize that issues of equity and equality exist in the power relations regarding which students have access and opportunity to interact with digital STEM-based makerspaces. Tan and Barton (2018) note that “opportunities to make, even in culturally sustaining ways, are always tied to, constrained by, or otherwise impacted by societal structures that shape those opportunities” (p. 49). This condition on the potential of technology use to be constrained by external forces supports Mrs. Trout’s interview data, in which she identified the structure of her online school as an *inhibitor* to actualizing CRE in a technology-rich environment. Given the context of Waterfall Online School, a school district with almost no diversity in student, teacher, or community population outside of the online school space, it is not surprising that the powers that designed and implemented the online school impacted the ability of the online space to be culturally relevant in a negative way.

The findings of this research, that technology can be both a *catalyst* and an *inhibitor* of culturally relevant STEM education, are supported by recent published research into the role of technology into culturally respecting STEM instruction. Teachers, teacher leaders, schools, and teacher preparation programs need to recognize and embrace that teaching and learning in the 21st century involves multiple technologies including online learning platforms and 1:1

classroom technology. The following recommendation is made based on the similarities of this research and concurrent published research findings regarding the role of technology in STEM education:

- 1) Teachers, teacher leaders, schools, and teacher preparation programs should work mindfully and intentionally towards establishing protocol for ensuring that technology-assisted education practices are conducted in a manner that recognizes and embraces the tenets of CRE, so that these technology-based platforms become *catalysts*, not *inhibitors*, of CRE.

The Role of Teacher Education

The role of teacher education (or what the role of teacher education should be) in preparing teachers to enact CRE in their classrooms is well described in the established literature that was reviewed prior to conducting this research (Fasching-Varner & Seriki, 2012; Hayes & Juarez, 2012; Ladson-Billings, 2001; Mensah, 2011; Sleeter, 2012; Wallace & Brand, 2012).

The importance of the role of teacher education in promoting CRE are based on evidences that teacher education programs can be effective in increasing the CRE aptitude of their teacher candidates. Kumar and Hamer (2012) provide one example of this evidence, in their four-year study examining biases of teacher candidates with regards to diverse students. Kumar and Hamer (2012) specifically examined the biases, and how these biases related to open-mindedness of instructional practices, of White teacher candidates at multiple checkpoints throughout a four-year, traditional teacher education program. The results of this study showed that teacher candidates with the lowest group of measurable bias were more willing to “adapt instruction to culturally diverse students” and more likely to “promote respect and collaboration in the classroom” than teacher candidates within the highest group of measurable bias (Kumar &

Hamer, 2012, p. 172). Additionally, Kumar and Hamer (2012) found that the measurable biases of teacher candidates were significantly reduced at the completion of the teacher preparation program, stating that “our findings support the hypothesis that the learning that occurs in a teacher-licensure program positively shapes the pre-service teachers’ attitudes toward culturally diverse students and encourages them to adopt adaptive classroom practices” (p. 172).

Evidences such as this, that show that traditional teacher preparation programs make a difference in the ability of students to enact culturally relevant educational practices, provide the foundation for the calls by (among others) Fasching-Varner and Seriki, 2012, Hayes and Juarez, 2012, and even the Council for the Accreditation of Educator Preparation (2018) for teacher education programs to center the importance of cultural diversity and culturally relevant education practices in all aspects of the teacher preparation process.

The findings of this study are not in disagreement with the above sentiments regarding the important role of teacher preparation in encouraging and supporting teacher candidates toward becoming a culturally relevant STEM educator. However, the findings of this study do highlight the need to bring additional considerations to the table when examining the role of teacher education with regard to teachers not being prepared to enact CRE, especially in STEM fields: the fact that an increasing number of STEM teachers enter the classroom through alternative pathways that do not involve traditional teacher education, and/or that STEM fields often experience out-of-field teachers.

Alternative Certifications and STEM Teachers. Teacher preparation is often discussed in the terms of traditional and alternative pathways towards becoming a licensed teacher. Traditional pathways refer to teacher preparation programs where the teacher candidate spends a considerable amount of post-secondary coursework studying education methods, theory, and

pedagogy, with additional clinical experiences as a part of this coursework to facilitate the learning of teaching skills and practices. Alternative pathways have a multiplicity of definitions: sometimes alternative pathways are defined as teacher candidates who first achieve a considerable achievement of coursework (or a degree) in a specific subject area, and then accomplish limited coursework and field experiences (usually not as much as in a traditional teacher preparation program) designed to support the teaching of that subject area. Additionally, alternative pathways are increasingly used to refer to teachers who have little or no formal educational coursework, training, or clinical practice at the time they begin teaching (Cochran-Smith & Villegas, 2015; Humphrey & Wechsler, 2007).

Regardless of the precise structure of the alternative preparation program, alternative teacher certification pathways are often proposed as the solution to fill teaching positions in high-needs subjects such as STEM. Alternative teacher preparation is also predicted to be a trend towards which teacher preparation is gravitating (Cochran-Smith & Power, 2010; Donitsa-Schmidt & Zuzovsky, 2014). As high-needs subject areas, STEM fields see larger percentages of teachers entering the profession through alternative pathways. USDE data reveals that 15% of new teachers, across all subjects, are prepared by alternative teacher preparation pathways, however, this percentage jumps to 21% for secondary mathematics and 26% for secondary sciences (USDE, 2015).

Implications Regarding Alternative Teacher Preparation. Evidence such as that presented by Kumar and Hamer (2012) shows that 4-year, traditional, CRE-respecting teacher preparation programs are effective in encouraging teacher candidates' classroom proficiencies towards CRE. The reality of STEM fields, however, is that a significant and increasing number of STEM teachers do not partake in a traditional teacher preparation program. Thus, a specific

recommendation of this research is that STEM teacher preparation programs reexamine and redesign alternative certification programs with direct and explicit relation to culturally relevant STEM education. While these alternative certification programs often originated as a solution to quickly fill the demand for STEM teachers (Cochran-Smith & Power, 2010; Donitsa-Schmidt & Zuzovsky, 2014), the time has come to expand the reach of these programs beyond simply being a solution to fill a documented teaching need. These STEM teaching positions need to be filled not just with content experts or those willing to teach in the STEM content, but with culturally relevant STEM educators.

Bowling and Ball (2018) describe a framework for re-evaluating alternative STEM-field teacher preparation programs in acknowledgement that alternative pathways are foreseeably permanent in the landscape of high-needs subject areas like STEM. They suggest teacher preparation taking a proactive stance with regard to alternative preparation programs that involves both holding alternative programs to high standards at the same time as pushing-back on the existence of “emergency preparation experiences” designed with minimal standards and requirements to quickly fill high-needs teaching vacancies (Bowling & Ball, 2018, p. 118). Additional suggestions for the reevaluation and redesign of alternative licensure programs focus on the increased need for induction support from the teacher preparation program that alternative teacher candidates often have when compared with traditional candidates (Bowling & Ball, 2018). Additionally, Bowling and Ball (2018) state that much more research is needed to inform the redesign of STEM alternative certification programs, in order to determine the most effective alternative certification programs and to codify the methods and characteristics that these effective programs have in common.

In agreement with the research needs to improve alternative certification programs, I propose that the findings of my study illustrate the need to mindfully incorporate CRE into alternative certification programs, and the need to evaluate the effectiveness of alternative certification programs in a similar manner to how Kumar and Hamer (2012) evaluated the effectiveness of traditional teacher preparation programs; in the specific context of the ability to influence a teacher candidate's inclinations towards and ability to enact CRE in the classroom setting.

Summary of Recommendations Involving the Role of Teacher Education and Alternative Certification.

- 1) In recognition of both the high percentages of STEM teachers entering the profession through alternative certification programs and permanence of alternative certification programs to fill the documented teacher shortage in high-needs subject areas, teacher education programs need to consider reevaluating and redesigning alternative preparation programs with intentionality and mindfulness to creating culturally relevant, alternatively certified STEM educators, and
- 2) Research measuring the effectiveness of alternative teacher preparation programs should define effectiveness at least in part with respect to the alternative program's impact on the CRE aptitudes of their teacher candidates.

Out-of-Field Teaching in STEM Subjects. In addition to traditional pathways and the multiple definitions of alternative pathways towards teaching, an additional teaching categorization exists; out-of-field teaching. Out-of-field teaching references teachers who teach a subject matter that they are not qualified to teach, based on a lack of content knowledge in that field and/or a lack of preparation to teach that particular subject matter (Ingersoll, 1998;

Ingersoll, 2002). 2012 National teacher workforce data indicates that 66.7% of middle school math teachers have degree and/or certification in mathematics and that 74.2% of middle school science teachers have a science degree or science teaching certification (NSB, 2016). The balance (33.3% for mathematics, 24.8% for science) are out-of-subject or underprepared teachers of math and science.

In this study, three of the six participants entered teaching through a traditional teacher preparation program. However, two of the three teachers who participated in a traditional teacher preparation program did so in elementary education, not in the secondary mathematics or science context that they currently teach. Therefore, just one of the teachers in this focus group of six cases entered the teaching profession both as an in-field teacher who matriculated through a traditional teacher preparation program. Although this focus group of cases is only six teachers, this anecdotal evidence echoes the data presented above regarding the presence of out-of-field STEM teachers (NSB, 2016). This research and the data presented above demonstrate that a significant portion of STEM teachers are out-of-field teachers. Given this finding, the implication is that the role of teacher education needs to be reexamined and discussed with specific regard to out-of-field teaching.

Implications Regarding Out-of-Field Teaching. Like alternative certification programs, out-of-field teaching is used to address teaching shortages in high-needs subject areas like STEM. Unlike alternative certification programs, which are gaining popularity as a method to address teacher shortages, out-of-field teaching is widely denounced as undesirable, emergency practice that can potentially have a negative impact on student learning. However, the current reality includes the use of out-of-field teachers in high-needs subject areas, such as STEM.

Like alternative licensure pathways, out-of-field teaching is more common in high-needs subject areas with documented teacher shortages than in areas with a large supply or surplus of teachers. NCES statistics show that Elementary schools are the least likely grade band to report hard-to-fill vacancies; only 8% of elementary school reported that they had at least one difficult to staff teaching position in 2011-2012, while for the same year 17% of middle schools and 28% of high schools reported hard-to-staff positions (Malkus, Hoyer, & Sparks, 2015). This problem is exacerbated by the demographics of the school looking for teachers: for each academic year from 1999-2012, public high schools with higher percentages of minority students reported more hard-to-fill positions across multiple subject areas than public high schools with less diversity (Malkus, Hoyer, & Sparks, 2015).

Given that NCES data shows that elementary grades are least likely to have hard-to-fill teaching positions, elementary grades teacher supply and demand were examined specifically in the state where this research occurred. Data from the state department of education for 2011 through 2016 academic years shows that less than 1% of out-of-field teachers in this state are elementary teachers. Additional data from the USDE (2016) shows that the state where this research occurred did not identify a shortage of elementary grades teachers in any of the academic school years from 2005-2017. In contrast, STEM fields were identified as high-needs fields in which the state was experiencing a shortage of teachers in these subjects every year from 2005-2017 (USDE, 2016). Given the surplus in elementary education teachers, and the shortage of STEM teachers, it is not surprising that teachers completing a traditional elementary education teacher preparation program end up teaching out-of-field in high needs STEM areas, as is the case for two of the six focus case participants represented in this research. Based on this

closer examination of out-of-field teaching in the specific context of secondary STEM education and the region where this research occurred, recommendations are issued below.

Summary of Recommendations Involving the Role of Teacher Education and Out-of-Field Teaching. To truly center the teacher preparation experience on CRE and prepare teacher candidates for the reality of what they may face in their own classroom, the CRE experiences and learning in low-needs subject areas and grade spans need to be directly applicable to high-needs grade spans and subject areas. This leads to the following recommendation and also the discussion of mastery learning and standards-based grading.

- 1) Teacher preparation programs need to be mindful of the reality that teachers prepared in low-needs subject areas and grade spans may well end up teaching in high-needs subjects and grade spans, such as secondary STEM.

Additional Recommendation: Mastery Learning and Standards-Based Grading. An additional recommendation to teacher education programs, in light of the persistence and prevalence of both alternatively certified STEM teachers and out of field STEM teachers, is to focus on high leverage CRE practices. I propose defining high-leverage CRE practices in this context as practices that are evidence-based, that can be taught within a timeline respective of alternative certification programs, and are able to be utilized and implemented across multiple content areas with respect to out-of-field teaching.

The high-leverage CRE practice I am specifically recommending be incorporated at the teacher education level is modeling the use of, and specifically teaching preservice teachers how to employ, the pedagogical and assessment strategy of teaching towards mastery and standards-based grading. Mastery learning/standards-based grading is discussed in the literature review of this research in the specific context of the CRE tenet of Academic Skills and Concepts. Mastery

learning or standards-based grading juxtaposes the more traditional grading methods referred to as performance-learning, where academic success is defined by successful achievement of a series of events, such as classroom assignments, worksheets, homework, quizzes, tests, and the often ill-defined concept of classroom participation (Kumar & Lauermann, 2018; Scarlett, 2018). Mastery learning/standards-based grading instead seeks to tie the grade in a course to actual acquisition of knowledge and skills, and provides students with flexibility in both assessment method and timeline of assessment to demonstrate that mastery (Marzano, 2010; Tomlinson & McTighe, 2006). Due to the building nature of STEM fields, it is imperative that students achieve mastery of academic concepts as students who do not achieve mastery of standards in the STEM classroom risk being left behind in the ability to persist in STEM education or pursue STEM careers (Anderman & Sinatra, 2009).

The attitudes towards and adaptation of mastery learning in the classroom has been shown to be directly relational to a teacher's "willingness to adjust instruction to the needs of culturally diverse students" (Kumar & Lauermann, 2018, p.433). Additionally, teachers use of instructional adaptations, like mastery learning, has been shown to correlate with "lower levels of negative stereotypical beliefs regarding minority students" as well as "lower than average beliefs that minority students should assimilate into the mainstream culture" (Kumar & Lauermann, 2018, p.433).

Despite the above evidence that teaching towards mastery and standards based grading correlate with culturally relevant education, mastery learning/standards-based grading has not gained popularity at the post-secondary level (Buckmiller, Peters, and Kruse, 2017, Scarlett, 2018). In examining the implementation of standards based grading in teacher preparation coursework, Buckmiller et al. (2017) found that despite initial student misgivings about being

graded based on their acquisition of knowledge rather than their completion of a series of assignments, 17 out of 21 students in the course reported that standards based grading had facilitated and enhanced their learning progress. Additional findings reported by the researchers are that students showed greater ownership of learning and responsibility for learning (Buckmiller et al., 2017). Three suggestions from this research for implementing standards-based grading in post-secondary teacher education were for instructors to identify their personal purpose with grading, to accept that grades should have a meaning related to acquisition of skills and concepts, and that flexibility and multiplicity need to be exercised when allowing students to demonstrate their acquisition of skills and concepts (Buckmiller et al., 2017).

Scarlett (2018) reported similar findings as Buckmiller et al. (2017) when reflecting on their implementation of standards-based grading into an undergraduate teacher education assessment course (thus effectively modeling culturally relevant assessment practices for their students). Like Buckmiller et al. (2017), Scarlett (2018) reported that the reactions from students were largely positive. She identified similar benefits of standards-based grading, such as an improvement in her meaningful communications with students, and higher course evaluation scores (Scarlett, 2018). Scarlett (2018) also described a similar step-wise process for implementation of standards based grading, first unpacking and clearly defining the learning targets, then choosing evidence of mastery related to these learning targets, then weighting these evidences in respect for the institution's need for a traditional letter grade in order to finalize a standards based grade.

Kumar & Lauermann (2018) provided evidence that mastery learning/standards-based grading correlates with culturally relevant educational practices. Scarlett (2018) and Buckmiller et al. (2017) exhibited evidence that despite a lack of current use, standards-based grading can be

successfully employed in post-secondary teacher education programs. Additionally, standards based grading has the characteristics of a high leverage CRE practice, as it can be taught within a streamlined timeline respective of alternative certification programs, and can be utilized regardless of content area, with respect to out-of-field teaching. Scarlett (2018) and Buckmiller et al. (2017) both describe simple, step-wise processes for implementing mastery learning/standards based grading. Similar checklists and overviews exist for secondary implementation as well (see Marzano, 2010; Tomlinson & McTighe, 2006). It seems that even reductionist and streamlined alternative teacher education programs could manage to integrate these simple steps and checklists. And, regarding out-of-field teaching, it is understandable that an out-of-field STEM teacher would struggle to connect their out-of-field content with issues of race, culture, special justice, or equity. It is asking a supreme amount of these out-of-field teachers to simply teach content that they did not specialize in. However, principles of mastery learning and standards based grading can be applied in the STEM classroom regardless of content knowledge or preparedness to teach that content.

Summary of Recommendations Involving Mastery Learning. Given the evidence that mastery learning can be successfully implemented at the teacher education level, and the evidence that mastery learning is related to other tenets of CRE, this research presents the following additional recommendations in relation to the role of teacher education in relation to their teacher candidates' abilities to implement CRE:

- 1) Low-demand teacher preparation subject areas should consider modeling and teaching mastery learning/standards-based grading, given the reality that their candidates may end up teaching out-of-field, and

- 2) As a part of the CRE-respecting design on alternative teacher preparation programs, these programs should model and teach mastery learning/standards-based grading, given that that mastery learning/standards-based grading can be taught respective to the time pressures experienced in the alternative certification experience.

The Role of the School

However impactful the role of teacher education is (or could be) towards catalyzing teachers towards culturally relevant STEM education, the teacher preparation program's reach is limited once the teacher candidate enters their own classroom within the context of their school. The foundations can be provided by and acquired by the teacher preparation program, but Mensah (2011) outlined the importance of having a community of practice within the school context to support and sustain culturally relevant educational practices in the classroom.

The role of the school teaching context in relation to teachers' abilities to implement culturally relevant STEM education warranted further discussion in this research based on the finding that the role of the school was the influence discussed most frequently in relation to implementing CRE across all focus case participants, and, across all of the multiple influences of CRE identified by this research, the role of the school displays the largest percentage of *inhibitor* categories when gating the data of all interview participants. Thus, it appears that the role of school offers an opportunity for improvement in the ability to support teachers' enactment of CRE in the STEM classroom.

To address this lack of support for culturally relevant practices in the school context, Mensah (2011) suggested that teacher education producing more culturally relevant educators can provide support at the school level for enacting culturally relevant STEM education. Not discounting the importance of a community of practice, nor the impact that teacher-leaders can

make at the school level, any conversation about school context and culture would not be complete without discussing the role of educational leadership.

Research on culturally respecting school administrative practices, like culturally relevant teaching practices, is an active research topic. This research, similar to the research on culturally relevant teaching practices, respects the realities that the teaching force is dominantly White, the student demographics are growing in diversity, and often growth and achievement learning gaps appear when comparing students of different races and ethnicities (Faas, Smith, & Darmody, 2018; Minkos, Sassau, Gregory, Patwa, Theodore, & Femc-Bagwell, 2017). These studies, and others on the topic of culturally relevant educational leadership, offer similar suggestions and directives aimed to assist school administrators in creating a safe and culturally responsive school environment for all learners.

Additionally, congruent to Tan and Barton's (2018) position that all STEM opportunities are tied to societal and external power structures, the same is true for school leadership. As Faas et al. (2018) observed, research into school leadership must be contextualized within the school boards and other district leadership that govern the school leadership. Just as the composite case of teachers in this research felt that the role of the school largely inhibited their ability to enact CRE in their STEM classrooms, school leadership may similarly feel that their ability to create a culturally respective school learning and teaching environment is inhibited by their governing or managing bodies. The implication is that the school board and/or superintendent could similarly shift blame for inhibiting CRE upstream to the state governing bodies, and this passing of responsibility could continue. Given that this research centers on the learning pathway of teachers in relation to culturally relevant STEM education (and not the learning pathways of school leaders or their various governing bodies), my further discussion based on the findings of

the role of the school that can either *catalyze* or *inhibit* culturally relevant STEM education shifts back to the role of the teacher within their schools.

While they often perceive their jobs to be overregulated and over-evaluated, the actuality is that secondary STEM teachers often operate under almost complete autonomy in their classrooms. Secondary STEM fields are largely untouched by prescriptive scripted curriculum models. In the state where this research occurred, secondary science and math have both undergone significant changes in standards over the past seven years. None of these changes were accompanied by a prescribed or scripted curriculum model for teachers to follow. Additionally, although the method of teacher evaluations is controversial in this area, the observation models used by the districts in this research allow for a maximum of six observations a year. When they occur, these supervised observations are for just a portion of a school day: they vary in length from 15 minutes to 90 minutes. Basic math demonstrates that for a school year that consists of 180 instructional days, teachers are officially observed a maximum of seven and a half hours. Additionally, these observation requirements decrease if teachers' students demonstrate above average yearly growth as determined by a state-approved value-added model. A teacher with the highest level of teacher effectiveness, as determined by this value-added model, can be officially observed for less than two hours per 180 instructional days, given the state-approved and mandated observation timeline. The lack of prescribed curriculum and the limited mandated supervised teaching time demonstrate that for the vast majority of their teaching time, secondary STEM teachers are operating independently in their classrooms, with admittedly little control over the concepts that they cover (as that is prescribed by standards), but the decisions on how to cover this material is under the control of the teacher.

The findings of this research show that the role of school can be an inhibitor of a STEM teacher enacting CRE. However, this research also provides an existence proof that culturally relevant STEM education can occur even when the teacher perceives the school to be an inhibitor of CRE. Mr. Redbud is the only focus case participant who showed no *undeveloped* categories for any tenet of CRE in his CRE profile; and he also perceived his school setting to be a large *inhibitor* of his ability to practice culturally relevant STEM education. Given this existence proof, and the realities of the secondary STEM classroom, the recommendation of this research in relation for the role of the school are as follows:

- 1) Teachers should be supported through whatever means necessary to realize the autonomy they have in their classrooms regarding how instructional content is presented, and
- 2) Teachers should actualize this power and parlay this power into enacting some level of culturally relevant STEM education.

Often, at both the teacher level and at the teacher education level, focus is maintained on the powers that we do not have to impact and implement change agents such as culturally relevant STEM education. This focus on lack of power is important to attempt to impact systemic and societal change, but does little to impact the learning, culturally relevant or otherwise, of students currently participating in this educational system. Actualizing and acting upon the powers that do exist, while simultaneously participating in critique of this power as necessary to improve the system as a whole, is necessary to improve outcomes for both current and future students.

Summary of Recommendations

The recommendations presented for this study are in response to the findings regarding multiple influences on teacher's abilities to actualize CRE in their STEM classrooms. While many of the recommendations originated from an examination of the findings regarding the role of schools and the role of technology, the summation of findings all relate to and have implications for teacher education. The summative recommendations of this study are listed below:

- 1) Teachers, teacher leaders, schools, and teacher preparation programs should work mindfully and intentionally towards establishing protocol for ensuring that technology-assisted education practices are conducted in a manner that recognizes and embraces the tenets of CRE, so that these technology-based platforms become *catalysts*, not *inhibitors*, of CRE.
- 2) In recognition of both the high percentages of STEM teachers entering the profession through alternative certification programs and permanence of alternative certification programs to fill the documented teacher shortage in high-needs subject areas, teacher education programs should consider reevaluating and redesigning alternative preparation programs with intentionality and mindfulness to creating culturally relevant, alternatively certified STEM educators.
- 3) As a part of the CRE-respecting design on alternative teacher preparation programs, these programs should model and teach mastery learning/standards-based grading.

- 4) Research measuring the effectiveness of alternative teacher preparation programs should define effectiveness at least in part with respect to the program's impact on the CRE aptitudes of their teacher candidates.
- 5) Teacher preparation programs need to be mindful of the reality that teachers prepared in low-needs subject areas and grade spans may well end up teaching in high-needs subjects and grade spans, such as secondary STEM.
- 6) Low-demand teacher preparation subject areas should consider modeling and teaching mastery learning/standards-based grading, given the reality that their candidates may end up teaching out-of-field.
- 7) Teachers should be supported through whatever means necessary to realize the autonomy they have in their classrooms regarding how instructional content is presented.
- 8) Teachers should actualize this power and parlay this power into enacting some level of culturally relevant STEM education.

Concluding Notes

The process of designing, implementing, and analyzing this research has been a challenge and a growth experience for me. First, it would be hard to write concluding thoughts about this research project without an acknowledgement of the timeline, and implications thereof, of this research project.

I became interested in this topic about eight years ago, and began actively working on this project two years ago. A great deal has changed in the past two years. I feel that this research is more important than ever, as we are living the result of what STEM education not respective

of cultural relevance will yield. Facts are no longer relevant, politics determines one's understanding or acceptance of science, and to think critically is to become "triggered." So, on one hand, I feel that this research is more important than ever.

However, I also see some missed opportunities in this research, that I plan to actualize in future research. One missed opportunity in this research was the lack of focus on intersectionality. I intentionally designed this project to explore an interesting disconnect between White teachers and students of Color. Clearly, now, I see the privilege associated with narrowing this research in that way. Culturally relevant education should additionally address issues of motivation, power, agency, and success of all genders as well as cultures.

An additional missed opportunity in this research was to assert myself during the interview process. Even though I specifically asked questions regarding race and culture, I repeatedly had interview participants revert to answering in terms they were more comfortable with, such as gender or socioeconomic status. I allowed this to happen and did not get the best data in certain circumstances as a result. I have learned from this process that critical research is inherently at least somewhat disruptive, and I have grown more comfortable with that role as a function of completing this process.

One of the things that caught my attention during this process is how much the teaching profession has changed in just the past three and a half years since I departed my classroom for the last time. For example, I left teaching when standardized tests took up four days of the school year. Now, a full six-weeks of the year is disrupted by scheduling around these tests, and many of the potteries of tests take 8 days to complete. This is a huge change in just 3.5 years. An additional example is the current classroom reality of teaching in a post-truth society, where students are encouraged by multiple external influences to simply not believe facts. For me, this

and other changes I observed serve as a reminder that an educational researcher needs to intentionally maintain contact with the classroom in order to maintain relevance.

Finally, I want to mention that when I started this project I self-identified as a classroom teacher. My perception of my profession was that I was a classroom STEM teacher, taking some time off from teaching to pursue my doctoral degree. I did not predict at that time that I would have a future in teacher education. Throughout this process, my own self-conceptions have changed. I am no longer a classroom teacher, I am a teacher education professional. If I completed this research as a classroom teacher, I am confident that my list of recommendations would all be in reference to what classroom teachers need to do. I would have crafted a list for my own self-responsibility towards solving the problem at hand.

I now identify as a teacher education professional, and predictably, my recommendations read like as a to-do list for teacher education. This list basically crafts my professional priorities moving forward, as I take full responsibility for enacting the recommendations of my research.

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Appendices

Appendix A: Graphics for Current Themes in Culturally Relevant STEM Education



CULTURAL COMPETENCE

IDENTITY LEARNING

Racial Identity

Cultural Identity

Academic/STEM Identity

affirmations

role models

learning setting

combatting deficit stereotypes

fostering motivation

PEDAGOGY IN ACTION

Integration of culture
into lesson

plans/learning activities

authentic pedagogy
ethnoscience instruction

REDUCTIONS

cultural relevance
vs. relevant to students.

making instruction relevant for
students confused with making
culturally relevant instruction.

STUDENT-TEACHER RELATIONSHIPS

multicultural
competence

teacher participation in
community

fostering motivation

correlations with
academic success

informing pedagogy

CRITICAL REFLECTION & CRITIQUE OF DISCOURSE OF POWER

PEDAGOGY INACTION

missed opportunities

- These two tenets of
- CRE were discussed as
- important in study
- rationale, but often
- missing from the
- studies themselves.

EXAMPLES IN CLASSROOM

(this section intentionally left blank.)

EXAMPLES DISPLAYED BY TEACHER

- reflective practice
 - iterative process
 - practitioner improvement
- not involving students
or modeling for students

EXAMPLES DISPLAYED BY RESEARCHER

- in theoretical framework
 - in research practice/methods
- modeling

Appendix B: Survey Questions

Survey adapted from the School Climate for Diversity Scales (Byrd, 2016, 2017, 2018)

Learning pathways towards or away from culturally relevant STEM teaching

In order to investigate the multitudes of influences in the learning pathways of STEM teachers, you are invited to participate in the following survey.

1. Informed consent

Agree – proceed to question #2.

Disagree – end survey

2. Are you a current teacher of a STEM (Science, Technology, Engineering, and/or Mathematics) subject in grades 6-12?

Yes – proceed to question #3

No – end survey

Section 1: The following questions will gather some basic information about you and your teaching career:

1. How many years have you been teaching?
 - a. 1-3
 - b. 4-6
 - c. 5-9
 - d. More than 9 years
2. What STEM subject best describes what you currently teach?
 - a. Science
 - b. Technology
 - c. Engineering
 - d. Mathematics
 - e. Other:
3. What best describes your current teaching environment
 - a. Public school
 - b. Private School
 - c. Afterschool or Educational Outreach program
 - d. Other:
4. Which option best describes your gender identity?
 - a. Female
 - b. Male
 - c. Transgender
 - d. I prefer not to answer
5. Which option best describes your racial or ethnic identity?
 - a. White/Caucasian
 - b. Black/African American
 - c. Latino/Latina/Hispanic

- d. Asian/Pacific Islander
- e. Native American
- f. Multiple Race/Ethnic identities
- g. Other:
- h. I prefer not to answer

Section 2: Your 6-12 educational experience. For the following questions, think about the schools you attended and the education you received in grades 6-12. If you prefer, focus on your educational experience in the grade that you currently teach.

1. The school you attended was
 - a. 1 (very diverse) – 5 (mostly one race or ethnicity)
2. The teachers and staff at your school were
 - a. 1 (very diverse) – 5 (mostly one race or ethnicity)
3. The surrounding community and parents thought highly of your school
 - a. 1 (strongly disagree – strongly agree)5
4. The students took pride in this school
 - a. 1 (strongly disagree – strongly agree)5
5. You learned about new cultures and traditions at school
 - a. 1 (strongly disagree – strongly agree)5
6. Teachers encouraged students to make friends with students of different races/ethnicities
 - a. 1 (strongly disagree – strongly agree)5
7. Teachers and principals seemed to value diversity
 - a. 1 (strongly disagree – strongly agree)5
8. Teachers encouraged awareness of social issues affecting your culture
 - a. 1 (strongly disagree – strongly agree)5
9. Your classes taught you about diverse cultures and traditions
 - a. 1 (strongly disagree – strongly agree)5
10. In your classes, you learned about how race and ethnicity can play a role in who is successful
 - a. 1 (strongly disagree – strongly agree)5
11. Students at your school often had friends among races/ethnicities other than their own:
 - a. 1 (strongly disagree – strongly agree)5
12. Your school provided opportunities to learn about social justice
 - a. 1 (strongly disagree – strongly agree)5

Now think about ONLY the STEM classes you took at your school.

13. Do you remember issues of race being taught or discussed in a STEM class?
 - a. 1 (never – frequently) 5
14. Do you remember issues of culture being taught or discussed in a STEM class?
 - a. 1 (never – frequently) 5
15. Did your STEM teachers recognize that race and culture play a role in STEM education?
 - a. 1 (never – frequently) 5
16. Do you remember talking about social justice or equity in a STEM class?
 - a. 1 (never – frequently) 5
17. Additional comments about the topics in this section:

Section 3: Your Teacher Education experience. For this section, think of the college or university you attended to prepare you to become a teacher. If you attended more than one, think about the college or university where you completed the majority of your teacher education coursework.

1. The college/university you attended was
 - a. 1 (very diverse) – 5 (mostly one race or ethnicity)
2. The faculty and staff at your college/university were:
 - a. 1 (very diverse) – 5 (mostly one race or ethnicity)
3. The surrounding community thought highly of your college/university:
 - a. 1 (strongly disagree – strongly agree)5
4. The students took pride in this college/university
 - a. 1 (strongly disagree – strongly agree)5
5. You learned about new cultures and traditions at this college/university
 - a. 1 (strongly disagree – strongly agree)5
6. Students at this college/university were encouraged to make friends with students of different races/ethnicities
 - a. 1 (strongly disagree – strongly agree)5
7. Faculty and staff seemed to value diversity
 - a. 1 (strongly disagree – strongly agree)5
8. Faculty and staff encouraged awareness of social issues affecting your culture
 - a. 1 (strongly disagree – strongly agree)5
9. Your classes taught you about diverse cultures and traditions
 - a. 1 (strongly disagree – strongly agree)5
10. In your classes, you learned about how race and ethnicity can play a role in who is successful
 - a. 1 (strongly disagree – strongly agree)5
11. Students at your college/university often had friends among races/ethnicities other than their own:
 - a. 1 (strongly disagree – strongly agree)5
12. Your college/university provided opportunities to learn about social justice
 - a. 1 (strongly disagree – strongly agree)5

Now think about ONLY the classes that taught you STEM content or teaching methods that you took at your college/university:

13. Do you remember issues of race being taught or discussed in a STEM class?
 - a. 1 (never – frequently) 5
14. Do you remember issues of culture being taught or discussed in a STEM class?
 - a. 1 (never – frequently) 5
15. Did your STEM faculty recognize that race and culture play a role in STEM education?
 - a. 1 (never – frequently) 5
16. Do you remember talking about social justice or equity in a STEM class?
 - a. 1 (never – frequently) 5
17. Additional comments about the topics in this section:

Section 4: Your teaching experience. For the following questions, think about the current school where you teach a STEM class.

4. My current school is
 - a. 1 (very diverse) – 5 (mostly one race or ethnicity)
5. The teachers and staff at your school are:
 - a. 1 (very diverse) – 5 (mostly one race or ethnicity)
6. The surrounding community and parents think highly of your school:
 - a. 1 (strongly disagree – strongly agree)5
7. The students take pride in this school
 - a. 1 (strongly disagree – strongly agree)5
8. Students learn about new cultures and traditions at your school
 - a. 1 (strongly disagree – strongly agree)5
9. Teachers encourage students to make friends with students of different races/ethnicities
 - a. 1 (strongly disagree – strongly agree)5
10. Teachers and principals seem to value diversity
 - a. 1 (strongly disagree – strongly agree)5
11. Teachers encourage awareness of social issues affecting your culture
 - a. 1 (strongly disagree – strongly agree)5
12. Students are taught about diverse cultures and traditions
 - a. 1 (strongly disagree – strongly agree)5
13. In your classes, students learn about how race and ethnicity can play a role in who is successful
 - a. 1 (strongly disagree – strongly agree)5
14. Students at your school often have friends among races/ethnicities other than their own:
 - a. 1 (strongly disagree – strongly agree)5
15. Your school provides opportunities to learn about social justice
 - a. 1 (strongly disagree – strongly agree)5

Now think about ONLY the STEM classes you teach at your school:

16. Are issues of race being taught or discussed in the STEM class(es) you teach?
 - a. 1 (never – frequently) 5
17. Are issues of culture being taught or discussed in the STEM class(es) you teach?
 - a. 1 (never – frequently) 5
18. As a STEM teacher, do you believe that race and culture play a role in STEM education?
 - a. 1 (never – frequently) 5
19. Do you or your students talk about social justice or equity in the STEM class(es) you teach?
 - a. 1 (never – frequently) 5
20. Additional comments about the topics in this section:

Section 5: Additional participation.

Thank you so much for participating in this survey! We appreciate your time to help with this research project. If you would be willing to participate in a follow-up interview to further help with this research project, please enter your email address in the box below and we will contact you. If not, simply leave the box blank and click “next” to end the survey. Again, thank you for your participation!

Appendix C: Sample Semi-Structured Interview Questions

Learning Progressions	
Sample questions arising from survey results:	In the survey you indicate that the (secondary school/post-secondary school) you attended (was/was not) diverse. <ol style="list-style-type: none"> Could you explain what characteristics of your school led you to indicate that is (was/was not) diverse? How do you think your experience at your school influenced how you teach?
	In the survey you indicate that the students at your (secondary school/post-secondary school) (did/did not) often have friends among races or ethnicities other than their own. How do you think this experience influences your teaching?
Additional interview questions:	Who or what motivated you to become a teacher?
	How do you think your learning experience at the secondary and post-secondary level influences your current teaching style or methods?
	What is the single-most influential moment of your teaching career?
	If you could choose one experience above all others outside of the school that has influenced your teaching, what would it be?

Culturally Relevant STEM Education: Academic Skills and Concepts:	
Sample questions arising from survey results:	In the survey, you indicated that the surrounding community (does/does not) think highly of your school. Why do you think this is so?
	In the survey, you indicated that students (do/do not) take pride in your school. Why do you think this is so?
Additional interview questions:	What is the biggest predictor of academic outcomes for students in your classes? Why do you think this is?
	How do you motivate students to continue with STEM education and STEM careers? Why do you believe these strategies will work?
	Do you notice a difference in achievement in your class based on gender? Based on race? What do you think contributes to achievement gaps? What is the best way to address and fix these gaps?
	What happens in your classroom if a student fails a test, or does not turn in an assignment? Why do you make these decisions? Who benefits most from this decision?

Culturally Relevant STEM Education: Cultural Competence:	
Sample questions arising from survey results:	In the survey, you indicated that teachers and principals at your school seem to (value/not value) diversity. Can you explain what events or policies led you to this conclusion?
	In the survey, you indicated that student (do/do not) learn about new cultures and traditions. Could you provide some examples of this, or some explanation of why this is not the case?
Sample additional interview questions:	How do you make sure you are meeting the needs of all students in your classes? How effectively do you feel that you are meeting the needs of all students in your class?
	Do you notice a difference in interest or motivation in your class based on a student's gender? Based on race?
	How do you approach students who you feel are underperforming or not meeting your expectations in your class? What other stakeholders should assume the responsibility for helping these students meet expectations?
	To what extent does your knowledge of your student's backgrounds impact your lesson planning? To what extent do you feel your students bring background knowledge and experiences with them into the classroom that can be useful to their STEM learning?
	Do you feel you can design and enact lessons that incorporate cultural or societal issues that your students face in their homes or communities? Why or why not?

Culturally Relevant STEM Education: Critical Reflection & Critique of Discourse of Power:	
Sample questions arising from survey results:	In the survey, you indicated that students at your school (do/do not) learn about how race and ethnicity can play a role in who is successful. Can you explain your answer?
	In the survey, you indicated that your school (does/does not) provide opportunities to learn about social justice. Can you explain your answer? (If the school does, could you provide an example? If the school does not, can you explain why you think that is?)
	On the survey, you indicated that you (do/do not) believe that race and culture play a role in STEM education. Can you explain your thinking behind your response?
	In the survey, you indicated that you or your students (do/do not) talk about social justice or equity in the STEM class(es) you teach. Can you explain your answer? (If you do, can you give an example? If you do not, can you explain why not?)
Additional interview questions:	<p>Data shows marked participation gaps among minority students in STEM higher education.</p> <ol style="list-style-type: none"> What is the role of the classroom STEM teacher in eliminating this gap? What is the role of the school? What is the role of society as a whole?
	We live in a society where certain scientific and mathematical models are becoming increasingly politicized and thus increasingly controversial. A few examples are climate change, vaccines, and evolution. How do you address these or other topics in your classroom in the context of the politicization or controversy? To what extent do you think teachers should engage with these potentially political, socioscientific issues in the classroom?
	In the past, science and math have struggled with equity and access issues, and the successes in these fields have largely been credited to white men. Do you feel that these issues of power and inequality have a role in today's science and math professions? Do you feel these issues should be addressed in the science and math classroom? If yes, how do you address these issues? If no, why not?
	Many science and math standards identify critical thinking and communication skills as fundamental to student success - not just in STEM - but in today's global economy. How does your instruction prepare students to be critical thinkers and communicators both inside and outside of your classroom?

Appendix D: Full Participation Survey Results

Secondary School Experience. The first section of the survey asked respondents to answer questions regarding their own secondary school and educational experience. Respondents were directed by the survey to think of the school that they attended during the grade that they currently teach. The first two questions asked about school diversity, as represented in Figure 1.

All Qualified Survey Respondents

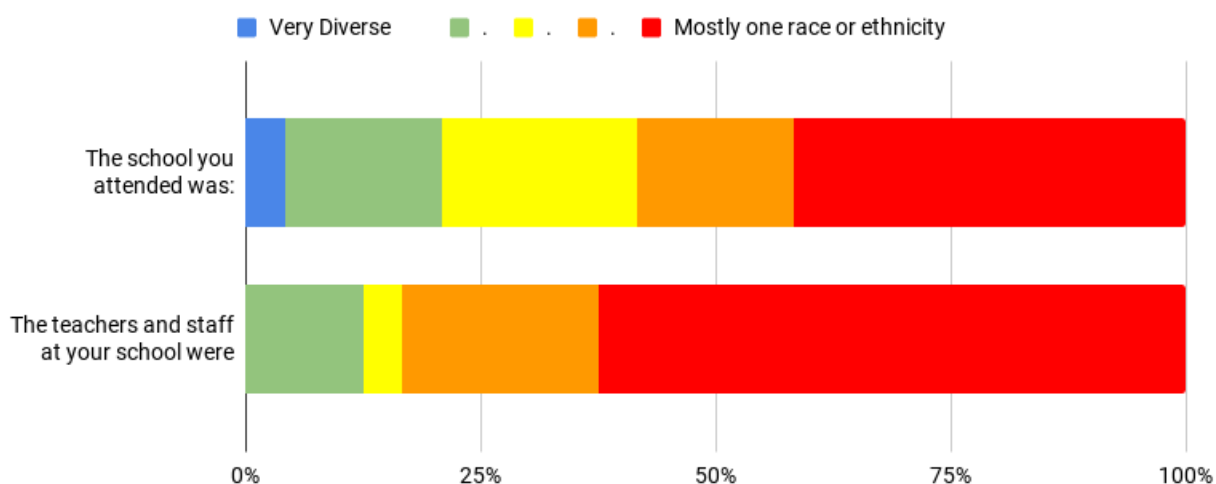


Figure 40: Diversity of Secondary School Experience

All Qualified Survey Respondents

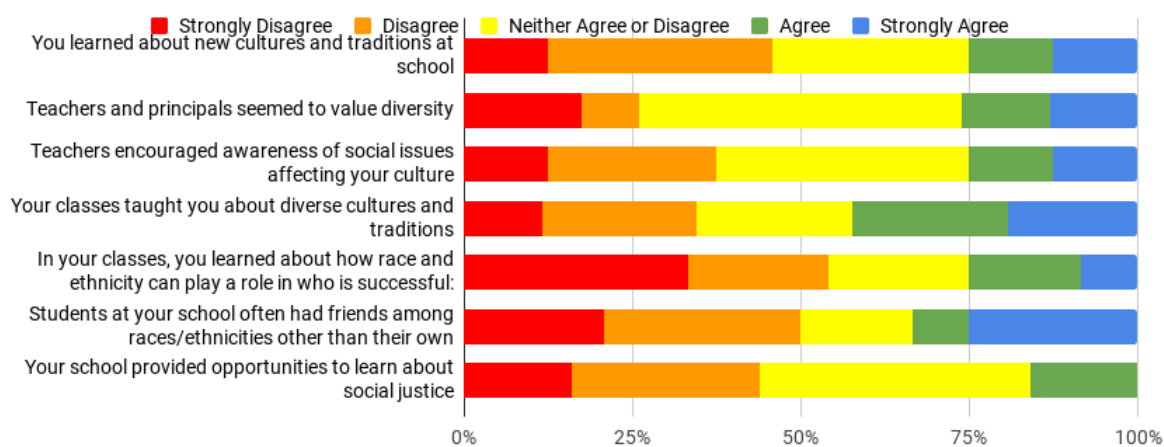


Figure 41: School Climate for Diversity Scale Responses

Still referencing their personal secondary school experience, participants were next asked a series of questions regarding the cultural climate of their experience, adapted from the School Climate for Diversity Scale (Byrd, 2016; Byrd, 2017; Byrd, 2018). Responses for the 24 survey participants to this set of questions are found in Figure 2.

Next, survey participants were asked to think about only the science, technology, engineering, and/or mathematics classes that they participated in during their secondary school experience. They were asked to respond to how frequently they remember issues of culture, social justice, and/or race being taught in their STEM classes they took at the secondary level. Additionally, they were prompted to respond to if their teachers recognized that issues of race and culture play a role in STEM education. Responses to this series of questions are found in Figure 45.

All Qualified Survey Respondents

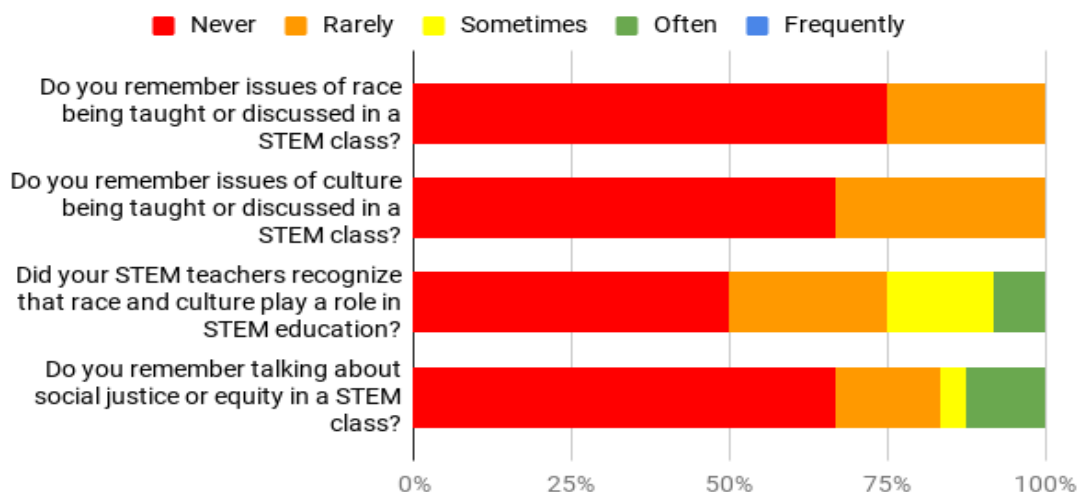


Figure 42 Secondary STEM Experiences

These results show that although some survey participants did attend secondary schools that they conceptualized or otherwise perceived as diverse, the majority did not perceive their secondary school to be diverse. Additionally, the lack of diversity in the secondary STEM teaching force that is discussed as a foundational premise of this research study is represented in

the survey results, given that 83% of survey respondents indicated that the faculty and staff at their school were not diverse.

Results of the responses for the School Climate for Diversity scale are more varied, with respondents indicating a variety of school experiences in relation to cultural relevance and cultural responsiveness. This is particularly interesting when compared to the next series of questions, when participants are asked to respond to questions just in relation to their STEM classes at the secondary level. When asked if their school as a whole provided the opportunity to learn about how race and ethnicity can play a role in who is successful, 25% of responses indicated agree or strongly agree. When asked specifically if their STEM teachers recognized that race and culture play a role in STEM education, only two respondents (8.3%) indicated in the affirmative. Similar observations can be made in regards to the questions pertaining to learning about culture at the school level and at the STEM level: almost half of participants (43%) indicated that their classes taught about diverse cultures and traditions, but when asked about STEM classes specifically, 100% of responses indicated that issues of culture were never or rarely taught or discussed in a STEM class.

All Qualified Survey Respondents

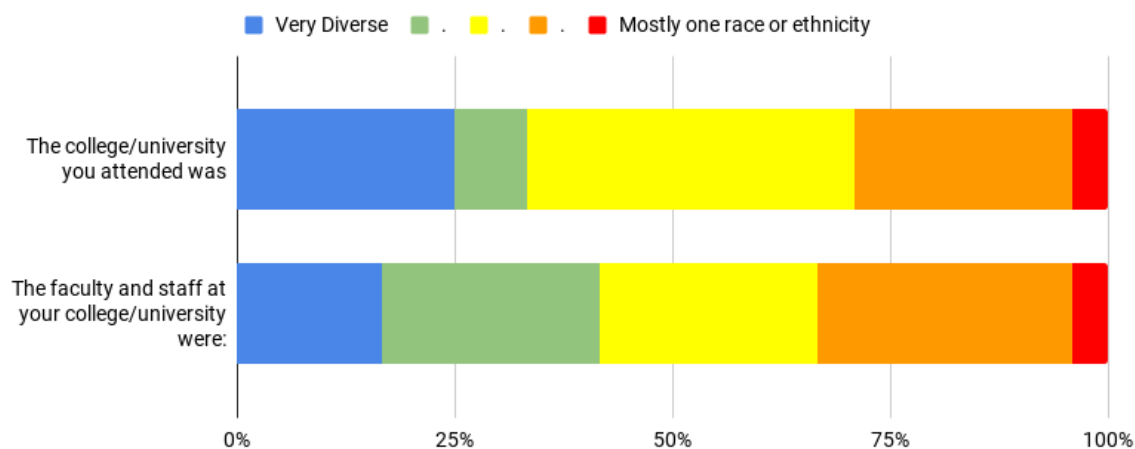


Figure 43: Diversity of Teacher Education Experience

Post-Secondary Education Experience. The next section of the survey asked participants to recall their teacher education experience. They were asked to recall their experience at the college or university they attended to prepare to become a teacher. The same series of questions were presented again; this time with the participant prompted to answer in regards to their teacher preparation program. Results for this section of the survey are found in Figure 45, Figure 46, and Figure 47.

All Qualified Survey Respondents

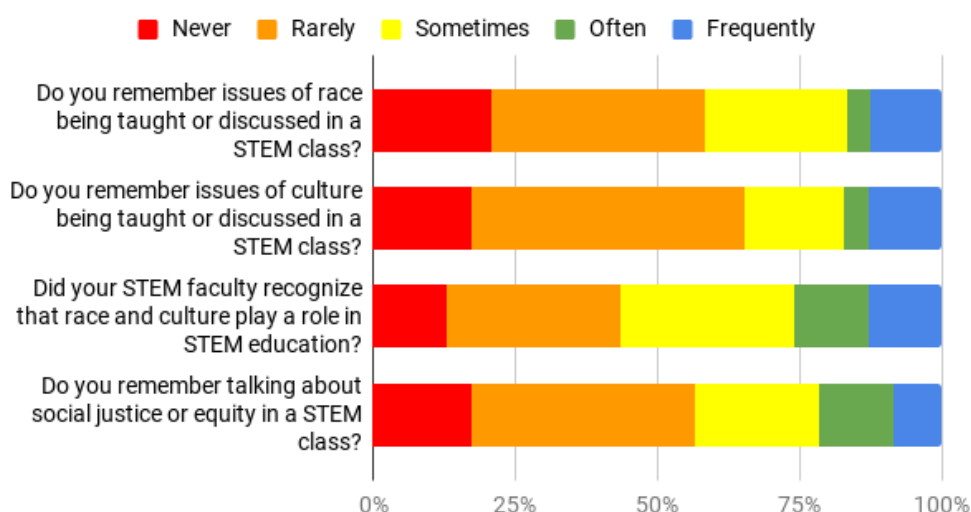


Figure 47: School Climate for Diversity Scale Responses

All Qualified Survey Respondents

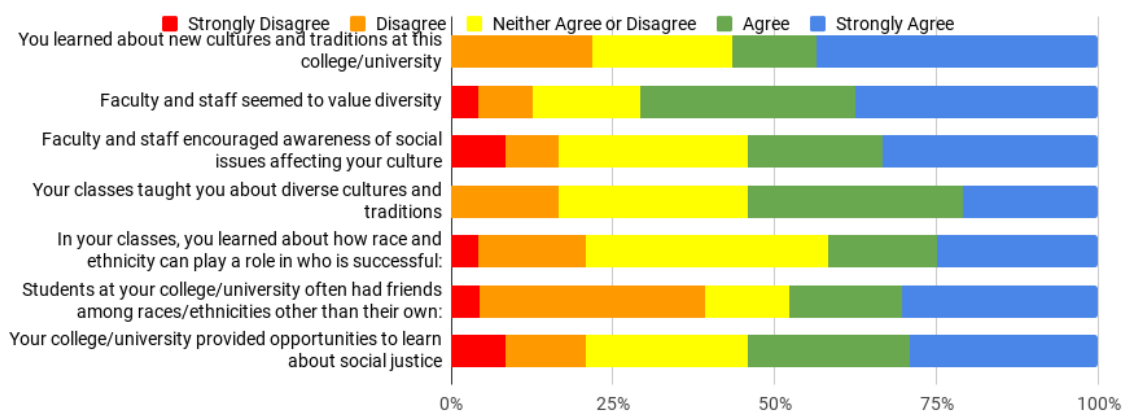


Figure 48: STEM Experience at the Teacher Education Level

These survey results show that the participant's perceptions of the presence of diversity increases when recalling their university or college experience, as compared to their own secondary education experience. Additionally, when recalling their post-secondary experience, almost all categories on the School Climate for Diversity scale yielded a majority positive (agree or strongly agree) response. Unlike the section of the survey that referred to secondary STEM education, in this section of the survey we see the appearance of recollections of critical pedagogy and multiculturalism in STEM courses. Almost 20% of respondents indicated that they frequently or often remember issues of race and culture being taught or discussed in a secondary STEM class. Additionally, over 20% of respondents remembered talking about issues of social justice or equity often or frequently in a post-secondary STEM class.

Secondary STEM Teaching Experience. The third and final series of questions in this survey asked participants to consider the school environment in which they currently teach a STEM content-area course. Overall, the survey respondents report that the schools in which they teach currently are more diverse than the schools in which they received their secondary education, which can be seen by comparing Figure 48 and Figure 45.

All Qualified Survey Respondents

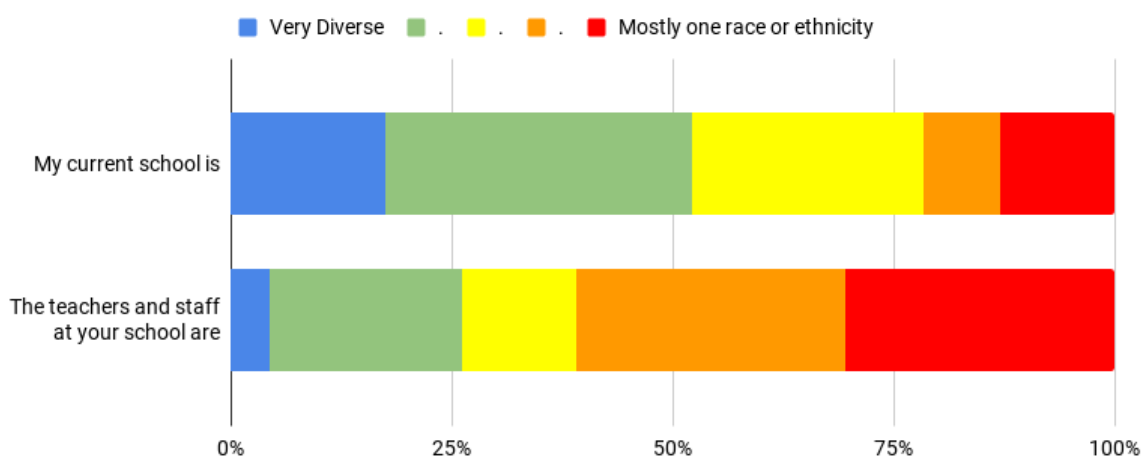


Figure 44: Diversity of Current Teaching Environment

Participants indicated that the school in which they currently teach were diverse (34.8%) or very diverse (17.4%), as compared to their recollections of the diversity of the secondary schools they attended (16.7% diverse and 4.2% very diverse).

Figure 49 shows the survey responses on the School Climate for Diversity scale in relation to the teachers' current school in which they teach a STEM subject. Comparing these results to the participant's conceptions of their own secondary school environment (Figure 2) shows that overall perceptions of the school climate towards diversity and multiculturalism have shifted, from the disagree and towards the agree end of the spectrum. For example, when asked of teachers and principals seemed to value diversity at the secondary school they attended, only 13% of participants indicated agree and 13% of participants indicated strongly agree. When asked this same question regarding the school where they currently teach, 34.8% indicated agree and an additional 39.1% of participants indicated strongly agree.

All Qualified Survey Respondents

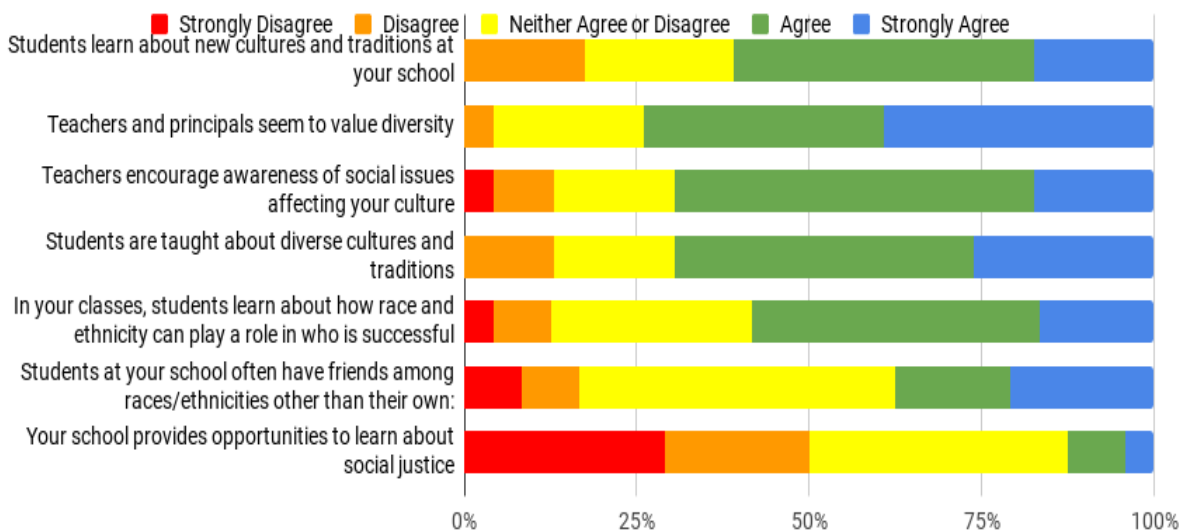


Figure 45: School Climate for Diversity Scale Responses

One interesting exception to this overall shift is the last question on both scales, regarding the opportunities that the school provides to learn about social justice. While the percentages in the different response categories have shifted, the findings remain similar in the percentage of respondents who indicated that their schools did/do not provide opportunities to learn about social justice. When asked if the school they attended provided opportunities to learn about social justice, 44% of respondents indicated disagree or strongly disagree. When asked the same question about the school where they currently teach, 50% of respondents indicated disagree or strongly disagree.

When respondents were asked to think of only the secondary STEM classes they teach in their schools (Figure 9), however, the responses change dramatically as compared to the respondents' conceptions of the STEM classes they were students in at the secondary level (Figure 3). When asked to recall their own secondary STEM education, zero respondents remembered issues of race or culture being taught or discussed in their STEM classes as the often or frequently level. As teachers, the same group reports that (12%) that issues of race are being taught or discussed often or frequently, and 20% report that issues of culture are being taught or discussed in their STEM classes often or frequently. Additionally, the perception regarding the role of race and culture in STEM education has shifted dramatically as reported by these teachers' perceptions of their 6-12 STEM experiences as compared to their conceptions as a STEM teacher

While this group of teachers as a whole is self-reporting the inclusion of issues of culture, race, and social justice in their own classrooms with greater frequency than they experienced at the secondary level, they are simultaneously reporting that they experienced more inclusion of

issues of race, culture, and social justice in STEM classes at the post-secondary level than they include in their own STEM classrooms.

All Qualified Survey Respondents

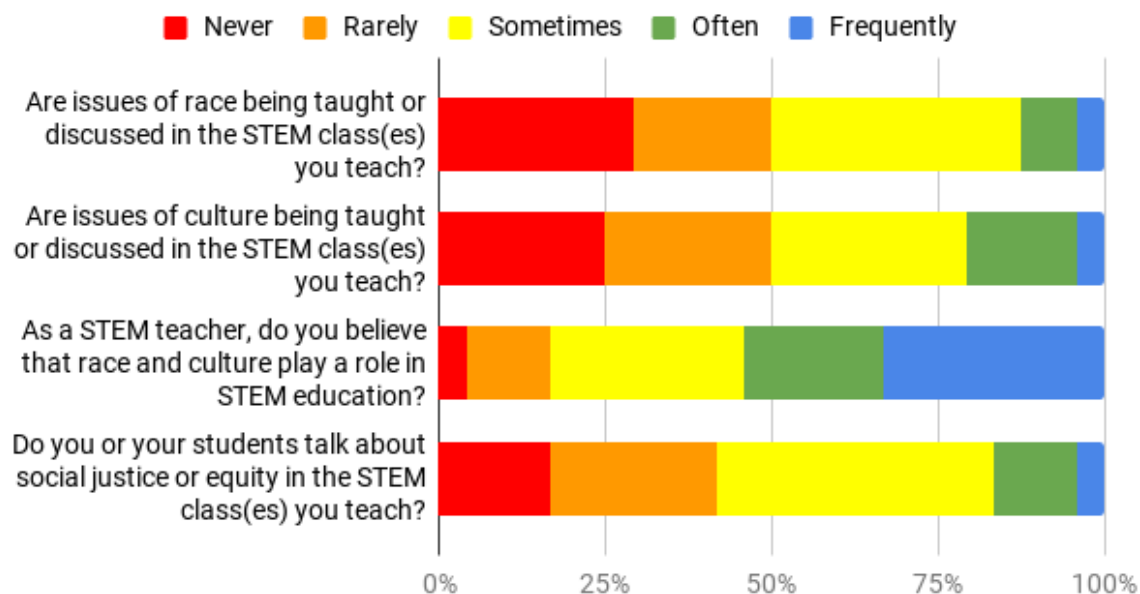


Figure 46: STEM Teaching Experience

Appendix E: Mrs. Dogwood's Full Survey Responses

Your 6-12 Educational Experience. For the following questions, think about the schools you attended and the education you received in grades 6-12. If you prefer, focus on your educational experience in the grade that you currently teach.	
Survey Question	Response
The school you attended was: 1 (very diverse - mostly one race or ethnicity) 5	5
The teachers and staff at your school were 1 (very diverse - mostly one race or ethnicity) 5	5
You learned about new cultures and traditions at school 1 (strongly disagree - strongly agree) 5	2
Teachers and principals seemed to value diversity 1 (strongly disagree - strongly agree) 5	2
Teachers encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	3
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	2
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	2
Students at your school often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	2
Your school provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	3
Now think about ONLY the STEM classes you took at your school: 1(never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	1
Do you remember issues of culture being taught or discussed in a STEM class?	1
Did your STEM teachers recognize that race and culture play a role in STEM education?	2
Do you remember talking about social justice or equity in a STEM class?	1

Your Teacher Education Experience. For this section, think of the college or university you attended to prepare you to become a teacher. If you attended more than one, think about the college or university where you completed the majority of your teacher education coursework.	
Survey Question	Response
The college/university you attended was 1 (very diverse - mostly one race or ethnicity) 5	1
The faculty and staff at your college/university were: 1 (very diverse - mostly one race or ethnicity) 5	1
You learned about new cultures and traditions at this college/university 1 (strongly disagree - strongly agree) 5	2
Faculty and staff seemed to value diversity 1 (strongly disagree - strongly agree) 5	1
Faculty and staff encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	1
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	2
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	2
Students at your college/university often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	1
Your college/university provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	1
Now think about ONLY the classes that taught you STEM content or teaching methods that you took at your college/university: 1 (never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	5
Do you remember issues of culture being taught or discussed in a STEM class?	5
Did your STEM faculty recognize that race and culture play a role in STEM education?	5
Do you remember talking about social justice or equity in a STEM class?	4

Your Teaching Experience. For the following questions, think about the current school where you teach a STEM class.

Survey Question	Response
My current school is 1 (very diverse - mostly one race or ethnicity) 5	2
The teachers and staff at your school are 1 (very diverse - mostly one race or ethnicity) 5	3
Students learn about new cultures and traditions at your school 1 (strongly disagree - strongly agree) 5	3
Teachers and principals seem to value diversity 1 (strongly disagree - strongly agree) 5	4
Teachers encourage awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	4
Students are taught about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	3
In your classes, students learn about how race and ethnicity can play a role in who is successful 1 (strongly disagree - strongly agree) 5	4
Students at your school often have friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	4
Your school provides opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	3
Now think about ONLY the STEM classes you teach at your school 1(never - frequently) 5	
Are issues of race being taught or discussed in the STEM class(es) you teach?	3
Are issues of culture being taught or discussed in the STEM class(es) you teach?	3
As a STEM teacher, do you believe that race and culture play a role in STEM education?	3
Do you or your students talk about social justice or equity in the STEM class(es) you teach?	3

Appendix F: Mr. Redbud's Full Survey Responses

Your 6-12 Educational Experience. For the following questions, think about the schools you attended and the education you received in grades 6-12. If you prefer, focus on your educational experience in the grade that you currently teach.

Survey Question	Response
The school you attended was: 1 (very diverse - mostly one race or ethnicity) 5	2
The teachers and staff at your school were 1 (very diverse - mostly one race or ethnicity) 5	5
You learned about new cultures and traditions at school 1 (strongly disagree - strongly agree) 5	5
Teachers and principals seemed to value diversity 1 (strongly disagree - strongly agree) 5	5
Teachers encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	5
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	4
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	5
Students at your school often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	3
Your school provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	1
Now think about ONLY the STEM classes you took at your school: 1 (never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	1
Do you remember issues of culture being taught or discussed in a STEM class?	1
Did your STEM teachers recognize that race and culture play a role in STEM education?	3
Do you remember talking about social justice or equity in a STEM class?	4

Your Teacher Education Experience. For this section, think of the college or university you attended to prepare you to become a teacher. If you attended more than one, think about the college or university where you completed the majority of your teacher education coursework.	
Survey Question	Response

The college/university you attended was 1 (very diverse - mostly one race or ethnicity) 5	4
The faculty and staff at your college/university were: 1 (very diverse - mostly one race or ethnicity) 5	4
You learned about new cultures and traditions at this college/university 1 (strongly disagree - strongly agree) 5	5
Faculty and staff seemed to value diversity 1 (strongly disagree - strongly agree) 5	5
Faculty and staff encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	5
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	5
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	5
Students at your college/university often had friends among races/ethnicities other than their own:1 (strongly disagree - strongly agree) 5	5
Your college/university provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	5
Now think about ONLY the classes that taught you STEM content or teaching methods that you took at your college/university: 1(never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	3
Do you remember issues of culture being taught or discussed in a STEM class?	3
Did your STEM faculty recognize that race and culture play a role in STEM education?	3
Do you remember talking about social justice or equity in a STEM class?	3

Your Teaching Experience. For the following questions, think about the current school where you teach a STEM class.	
Survey Question	Response
My current school is 1 (very diverse - mostly one race or ethnicity) 5	3

The teachers and staff at your school are 1 (very diverse - mostly one race or ethnicity) 5	5
Students learn about new cultures and traditions at your school 1 (strongly disagree - strongly agree) 5	5
Teachers and principals seem to value diversity 1 (strongly disagree - strongly agree) 5	5
Teachers encourage awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	5
Students are taught about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	5
In your classes, students learn about how race and ethnicity can play a role in who is successful 1 (strongly disagree - strongly agree) 5	5
Students at your school often have friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	3
Your school provides opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	3
Now think about ONLY the STEM classes you teach at your school 1 (never - frequently) 5	
Are issues of race being taught or discussed in the STEM class(es) you teach?	3
Are issues of culture being taught or discussed in the STEM class(es) you teach?	3
As a STEM teacher, do you believe that race and culture play a role in STEM education?	3
Do you or your students talk about social justice or equity in the STEM class(es) you teach?	3

Appendix G: Mr. Wildflower's Full Survey Responses

Your 6-12 Educational Experience. For the following questions, think about the schools you attended and the education you received in grades 6-12. If you prefer, focus on your educational experience in the grade that you currently teach.	
Survey Question	Response
The school you attended was: 1 (very diverse - mostly one race or ethnicity) 5	5

The teachers and staff at your school were 1 (very diverse - mostly one race or ethnicity) 5	5
You learned about new cultures and traditions at school 1 (strongly disagree - strongly agree) 5	3
Teachers and principals seemed to value diversity 1 (strongly disagree - strongly agree) 5	3
Teachers encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	3
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	3
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	3
Students at your school often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	3
Your school provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	2
Now think about ONLY the STEM classes you took at your school: 1 (never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	2
Do you remember issues of culture being taught or discussed in a STEM class?	2
Did your STEM teachers recognize that race and culture play a role in STEM education?	2
Do you remember talking about social justice or equity in a STEM class?	1

Your Teacher Education Experience. For this section, think of the college or university you attended to prepare you to become a teacher. If you attended more than one, think about the college or university where you completed the majority of your teacher education coursework.	
Survey Question	Response
The college/university you attended was 1 (very diverse - mostly one race or ethnicity) 5	1
The faculty and staff at your college/university were: 1 (very diverse - mostly one race or ethnicity) 5	1

You learned about new cultures and traditions at this college/university 1 (strongly disagree - strongly agree) 5	5
Faculty and staff seemed to value diversity 1 (strongly disagree - strongly agree) 5	5
Faculty and staff encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	4
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	3
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	3
Students at your college/university often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	5
Your college/university provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	5
Now think about ONLY the classes that taught you STEM content or teaching methods that you took at your college/university: 1 (never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	5
Do you remember issues of culture being taught or discussed in a STEM class?	5
Did your STEM faculty recognize that race and culture play a role in STEM education?	5
Do you remember talking about social justice or equity in a STEM class?	5

Your Teaching Experience. For the following questions, think about the current school where you teach a STEM class.	
Survey Question	Response
My current school is 1 (very diverse - mostly one race or ethnicity) 5	1
The teachers and staff at your school are 1 (very diverse - mostly one race or ethnicity) 5	4
Students learn about new cultures and traditions at your school 1 (strongly disagree - strongly agree) 5	4

Teachers and principals seem to value diversity 1 (strongly disagree - strongly agree) 5	5
Teachers encourage awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	4
Students are taught about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	4
In your classes, students learn about how race and ethnicity can play a role in who is successful 1 (strongly disagree - strongly agree) 5	4
Students at your school often have friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	3
Your school provides opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	5
Now think about ONLY the STEM classes you teach at your school 1 (never - frequently) 5	
Are issues of race being taught or discussed in the STEM class(es) you teach?	4
Are issues of culture being taught or discussed in the STEM class(es) you teach?	4
As a STEM teacher, do you believe that race and culture play a role in STEM education?	5
Do you or your students talk about social justice or equity in the STEM class(es) you teach?	3

Appendix H: Mrs. Clover's Full Survey Responses

Your 6-12 Educational Experience. For the following questions, think about the schools you attended and the education you received in grades 6-12. If you prefer, focus on your educational experience in the grade that you currently teach.	
Survey Question	Response
The school you attended was: 1 (very diverse - mostly one race or ethnicity) 5	5
The teachers and staff at your school were 1 (very diverse - mostly one race or ethnicity) 5	5
You learned about new cultures and traditions at school 1 (strongly disagree - strongly agree) 5	3

Teachers and principals seemed to value diversity 1 (strongly disagree - strongly agree) 5	3
Teachers encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	3
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	4
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	4
Students at your school often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	2
Your school provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	3
Now think about ONLY the STEM classes you took at your school: 1 (never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	1
Do you remember issues of culture being taught or discussed in a STEM class?	2
Did your STEM teachers recognize that race and culture play a role in STEM education?	1
Do you remember talking about social justice or equity in a STEM class?	2

Your Teacher Education Experience. For this section, think of the college or university you attended to prepare you to become a teacher. If you attended more than one, think about the college or university where you completed the majority of your teacher education coursework.	
Survey Question	Response
The college/university you attended was 1 (very diverse - mostly one race or ethnicity) 5	3
The faculty and staff at your college/university were: 1 (very diverse - mostly one race or ethnicity) 5	3
You learned about new cultures and traditions at this college/university 1 (strongly disagree - strongly agree) 5	3
Faculty and staff seemed to value diversity 1 (strongly disagree - strongly agree) 5	4

Faculty and staff encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	4
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	4
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	4
Students at your college/university often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	2
Your college/university provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	3
Now think about ONLY the classes that taught you STEM content or teaching methods that you took at your college/university: 1 (never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	2
Do you remember issues of culture being taught or discussed in a STEM class?	2
Did your STEM faculty recognize that race and culture play a role in STEM education?	3
Do you remember talking about social justice or equity in a STEM class?	2

Your Teaching Experience. For the following questions, think about the current school where you teach a STEM class.	
Survey Question	Response
My current school is 1 (very diverse - mostly one race or ethnicity) 5	3
The teachers and staff at your school are 1 (very diverse - mostly one race or ethnicity) 5	4
Students learn about new cultures and traditions at your school 1 (strongly disagree - strongly agree) 5	3
Teachers and principals seem to value diversity 1 (strongly disagree - strongly agree) 5	4
Teachers encourage awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	4

Students are taught about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	4
In your classes, students learn about how race and ethnicity can play a role in who is successful 1 (strongly disagree - strongly agree) 5	3
Students at your school often have friends among races/ethnicities other than their own:1 (strongly disagree - strongly agree) 5	3
Your school provides opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	3
Now think about ONLY the STEM classes you teach at your school 1(never - frequently) 5	
Are issues of race being taught or discussed in the STEM class(es) you teach?	3
Are issues of culture being taught or discussed in the STEM class(es) you teach?	4
As a STEM teacher, do you believe that race and culture play a role in STEM education?	4
Do you or your students talk about social justice or equity in the STEM class(es) you teach?	3

Appendix I: Mrs. Nimbus's Full Survey Responses

Your 6-12 Educational Experience. For the following questions, think about the schools you attended and the education you received in grades 6-12. If you prefer, focus on your educational experience in the grade that you currently teach.	
Survey Question	Response
The school you attended was: 1 (very diverse - mostly one race or ethnicity) 5	5
The teachers and staff at your school were 1 (very diverse - mostly one race or ethnicity) 5	5
You learned about new cultures and traditions at school 1 (strongly disagree - strongly agree) 5	2
Teachers and principals seemed to value diversity 1 (strongly disagree - strongly agree) 5	3
Teachers encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	4

Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	4
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	2
Students at your school often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	2
Your school provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	3
Now think about ONLY the STEM classes you took at your school: 1 (never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	2
Do you remember issues of culture being taught or discussed in a STEM class?	2
Did your STEM teachers recognize that race and culture play a role in STEM education?	3
Do you remember talking about social justice or equity in a STEM class?	2

Your Teacher Education Experience. For this section, think of the college or university you attended to prepare you to become a teacher. If you attended more than one, think about the college or university where you completed the majority of your teacher education coursework.	
Survey Question	Response
The college/university you attended was 1 (very diverse - mostly one race or ethnicity) 5	3
The faculty and staff at your college/university were: 1 (very diverse - mostly one race or ethnicity) 5	2
You learned about new cultures and traditions at this college/university 1 (strongly disagree - strongly agree) 5	4
Faculty and staff seemed to value diversity 1 (strongly disagree - strongly agree) 5	4
Faculty and staff encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	4
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	4

In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	3
Students at your college/university often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	4
Your college/university provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	3
Now think about ONLY the classes that taught you STEM content or teaching methods that you took at your college/university: 1 (never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	2
Do you remember issues of culture being taught or discussed in a STEM class?	2
Did your STEM faculty recognize that race and culture play a role in STEM education?	3
Do you remember talking about social justice or equity in a STEM class?	2

Your Teaching Experience. For the following questions, think about the current school where you teach a STEM class.	
Survey Question	Response
My current school is 1 (very diverse - mostly one race or ethnicity) 5	3
The teachers and staff at your school are 1 (very diverse - mostly one race or ethnicity) 5	2
Students learn about new cultures and traditions at your school 1 (strongly disagree - strongly agree) 5	4
Teachers and principals seem to value diversity 1 (strongly disagree - strongly agree) 5	4
Teachers encourage awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	4
Students are taught about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	4
In your classes, students learn about how race and ethnicity can play a role in who is successful 1 (strongly disagree - strongly agree) 5	3

Students at your school often have friends among races/ethnicities other than their own:1 (strongly disagree - strongly agree) 5	4
Your school provides opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	3
Now think about ONLY the STEM classes you teach at your school 1(never - frequently) 5	
Are issues of race being taught or discussed in the STEM class(es) you teach?	2
Are issues of culture being taught or discussed in the STEM class(es) you teach?	2
As a STEM teacher, do you believe that race and culture play a role in STEM education?	3
Do you or your students talk about social justice or equity in the STEM class(es) you teach?	2

Appendix J: Mrs. Trout's Full Survey Responses

Your 6-12 Educational Experience. For the following questions, think about the schools you attended and the education you received in grades 6-12. If you prefer, focus on your educational experience in the grade that you currently teach.	
Survey Question	Response
The school you attended was: 1 (very diverse - mostly one race or ethnicity) 5	3
The teachers and staff at your school were 1 (very diverse - mostly one race or ethnicity) 5	3
You learned about new cultures and traditions at school 1 (strongly disagree - strongly agree) 5	1
Teachers and principals seemed to value diversity 1 (strongly disagree - strongly agree) 5	1
Teachers encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	1
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	1
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	1

Students at your school often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	4
Your school provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	1
Now think about ONLY the STEM classes you took at your school: 1 (never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	1
Do you remember issues of culture being taught or discussed in a STEM class?	1
Did your STEM teachers recognize that race and culture play a role in STEM education?	1
Do you remember talking about social justice or equity in a STEM class?	1

Your Teacher Education Experience. For this section, think of the college or university you attended to prepare you to become a teacher. If you attended more than one, think about the college or university where you completed the majority of your teacher education coursework.	
Survey Question	Response
The college/university you attended was 1 (very diverse - mostly one race or ethnicity) 5	3
The faculty and staff at your college/university were: 1 (very diverse - mostly one race or ethnicity) 5	3
You learned about new cultures and traditions at this college/university 1 (strongly disagree - strongly agree) 5	4
Faculty and staff seemed to value diversity 1 (strongly disagree - strongly agree) 5	5
Faculty and staff encouraged awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	5
Your classes taught you about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	5
In your classes, you learned about how race and ethnicity can play a role in who is successful: 1 (strongly disagree - strongly agree) 5	4
Students at your college/university often had friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	4

Your college/university provided opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	5
Now think about ONLY the classes that taught you STEM content or teaching methods that you took at your college/university: 1 (never - frequently) 5	
Do you remember issues of race being taught or discussed in a STEM class?	2
Do you remember issues of culture being taught or discussed in a STEM class?	1
Did your STEM faculty recognize that race and culture play a role in STEM education?	3
Do you remember talking about social justice or equity in a STEM class?	2

Your Teaching Experience. For the following questions, think about the current school where you teach a STEM class.	
Survey Question	Response
My current school is 1 (very diverse - mostly one race or ethnicity) 5	2
The teachers and staff at your school are 1 (very diverse - mostly one race or ethnicity) 5	
Students learn about new cultures and traditions at your school 1 (strongly disagree - strongly agree) 5	4
Teachers and principals seem to value diversity 1 (strongly disagree - strongly agree) 5	3
Teachers encourage awareness of social issues affecting your culture 1 (strongly disagree - strongly agree) 5	4
Students are taught about diverse cultures and traditions 1 (strongly disagree - strongly agree) 5	2
In your classes, students learn about how race and ethnicity can play a role in who is successful 1 (strongly disagree - strongly agree) 5	1
Students at your school often have friends among races/ethnicities other than their own: 1 (strongly disagree - strongly agree) 5	4
Your school provides opportunities to learn about social justice 1 (strongly disagree - strongly agree) 5	1

Now think about ONLY the STEM classes you teach at your school 1(never - frequently) 5	
Are issues of race being taught or discussed in the STEM class(es) you teach?	1
Are issues of culture being taught or discussed in the STEM class(es) you teach?	1
As a STEM teacher, do you believe that race and culture play a role in STEM education?	5
Do you or your students talk about social justice or equity in the STEM class(es) you teach?	1

Vita

Amelia Brown received her undergraduate degree in Agronomic Crop Production from the University of Florida before deciding to pursue a career in science education. She received her Master's in Science Education from the University of Tennessee and taught middle grades science in a high-needs school before deciding to pursue her Ph.D. Her research interests center on appropriate use of data and technology in education, culturally relevant STEM education, and equitable promotion and teaching of scientific literacy.